Essays in Macro-Finance

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Abstract

This thesis deals with the economics of crises, within the macro-finance literature.

The first chapter, coauthored with Rasmus Pank, deals with how crises emerge. Particularly, we are interested in how *confidence* affects the outcomes in an experimental asset market where the fundamental value is known by all the participants. We elicit expectations in a way that allows us to measure confidence. We ask participants to forecast the one-period-ahead price as a discrete probability mass distribution and find that confidence not only affects the price-formation in markets, but also is important in explaining the dynamics of the bubble. Moreover, as traders' confidence grows, they become increasingly more optimistic, thus increasing the likelihood of price bubbles.

The remaining chapters deal with policy responses to crises.

The second chapter, "Banks vs Zombies", studies how zombie firms arise in equilibrium and the scope for policy. Zombie firms are otherwise insolvent borrowers who are kept afloat by new credit from banks to cover their losses. The practice, known as evergreening or zombie lending, has occurred in times of financial distress even when debt restructuring is allowed. I study the incentives to restructure debt in a borrower-lender game and provide conditions under which it is optimal to engage in evergreening even when socially inefficient. In normal times, the borrower can access a competitive credit market and pay the opportunity cost of capital. When a shock renders the creditor insolvent, debt needs to be restructured. The firm is locked in a lending relationship and the incumbent bank has monopoly power. Normally, a lender would liquidate the firm. However, the lender is also financially distressed, the incentives to restructure change radically. To keep the firm afloat and prevent its own bankruptcy, the bank covers the firms' losses. It does not, however, fund investment, as the distressed borrower may not use the funds efficiently. Evergreening can happen for profitable investments and renegotiation does not solve the problem. I discuss policy alternatives and show that debt haircuts and bank capitalizations must be used simultaneously; and that monetary policy can behave differently in the presence of zombie firms. Finally, I provide evidence supporting the model using a novel panel data set of matched firms and banks for the case of Spain.

The final chapter, "Optimal Haircuts", analyzes the desirability of intervention

in a simple model of heterogeneous firms and households. Households finance firm's working capital, and the credit constrained firms are heterogeneous in their productivity and hence debt levels. After an unexpected aggregate shock, less productive firms go bankrupt. This directly decreases the wage income of the households, and indirectly decreases their income from the defaulted loans to firms. The main result of the paper is that there is an optimal haircut for deposits such that both firms and families are better off. Moreover, there is a tension between maximizing welfare and maximizing output. This provides a rationale for the Cypriot, Hungarian and Argentinean experience. The model is adapted to an open economy and used to analyze a devaluation shock, which provides policy for countries attempting to escape a monetary union or a currency peg.

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[1]This chapter is coauthored with Rasmus Pank.

Chapter 1

Certainty and Decision-Making in Experimental Asset Markets

1.1 Introduction[1]

Expectation formation is of central importance to understand price formation and their fluctuations in asset markets (See for example Fisher and Statman (2000)).

Since Smith et al. (1988), trader expectations have largely been studied in an experimental setup since measuring them in practice is challenging and fundamental values are unknown. A major shortcoming of the literature is that it at most elicits expectations as point forecasts rather than as proper distributions of beliefs. In fact, confidence has no role in most studies. In this paper we carefully design a setup to understand the role of confidence and trader expectations in the creation of bubbles in asset markets. Our main contribution is to examine the effect of both trader and market confidence on price dynamics in experimental asset markets.

We use the workhorse of experimental finance (following Smith et al. (1988)) augmented with a novel way of eliciting beliefs based on Harrison et al. (2012). Subjects participate in an experimental session consisting of 2 or 3 markets, each of which lasts for either 15 periods or 12 periods, respectively. There is a single asset in the market which pays a random dividend from a known, fixed distribution in each period. Each subject must make predictions and trade the asset. Trading is conducted as in Haruvy et al. (2007): in each period, agents can buy and sell assets. However, before trade is conducted, traders are asked to forecast the price in the same period (before it has been determined). Traders are endowed with 20 tokens which they can use to assess the likelihood of a given price range. In this way, we can elicit distribution of beliefs about prices which further allow us to analyze the impact of confidence on the market dynamics. To avoid any potential hedging between the two tasks, participants

[1]This chapter is coauthored with Rasmus Pank.

are randomly rewarded at the end of the game for either trading or forecasting. In this way, we can address the impact on price dynamics of traders' certainty over expected future prices and an aggregate measure of these, which we denote *market sentiment*.

We first analyze how confidence evolves at the individual level and show that successful traders become more confident with accurate forecasts. Secondly, we find that traders expectations converge as they are more experienced. Thirdly, we find that the size of the bubble is amplified when traders expectations are less scattered.Finally, we find that confidence is a relevant variable to understand future price movements. This sheds some light on the Financial stability hypothesis by Minsky (1992).

The rest of the paper is structured as follows. Section 1.2 reviews the state of the theoretical and empirical literature with special emphasis on the bubbles in asset markets. Section 1.3 describes the hypotheses that guide our experimental design, presented in Section 1.4, and our analysis in Section 1.6. Section 1.7 concludes.

1.2 Literature Review

The experimental literature on bubbles dates back to the seminal contribution by Smith et al. (1988). In their setup, typically nine participants are endowed with different amounts of cash and assets and can trade during several 15 round *markets*. The Smith et al. (1988) setup has been the workhorse for experimental asset market research for the last 30 years, covering many areas of trading including the role of traders' characteristics (experience, education, sentiments, etc.), public announcements, liquidity, short selling, dividends, capital gains taxes, insider information, among others (See Palan (2013) for a recent survey). Although the fundamental value of the asset is known in every round, a common feature of these models is that bubbles emerge. However, until Haruvy et al. (2007) the literature had not carefully addressed the impact of expectations. Haruvy et al. (2007) set up an experiment almost identical to Smith et al. (1988), where they elicit forecasts about future prices from subjects. We build upon Haruvy et al. (2007) given the large body of literature that Smith et al. (1988) has inspired. We extend and complement this research by eliciting confidence of participants.

There is a vast theoretical literature on expectations and financial bubbles. From the no-trade theorems it follows that private information alone cannot explain bubbles Milgrom and Stokey (1982). Moreover, Tirole (1982) shows that *speculative bubbles*—those, in which speculative investors buy an over-priced asset to sell it to a *greater fool* before the crash—cannot arise in rational expectations models. Thus, many papers have relied on so-called "irrational" behavior or myopia to explain them (see e.g. Abreu and Brunnermeier, 2003). Most of the models that explain bubbles focus on two issues: coordination and dispersion of opinion. If a trader expects the asset price to soar, he may be willing to buy the asset even at price above its fundamental value, given the possibility of reselling at a later time. As long as the moment of the crash is unknown, traders might be tempted to ride the bubble, hoping to sell before it bursts.

Another strand of the literature, focuses on overconfident agents (See for example Scheinkman and Xiong (2003)). Agents believe that their information is superior to that of the general market, and fail to adjust their beliefs as they observe others' beliefs. Our framework contributes to understand the validity of these theories.

Brock and Hommes (1997) provide models of asset trading based on the interaction of traders' with heterogeneous expectations, giving rise to dynamics akin to those observed in real-world stock prices. Boswijk et al. (2007) and Barberis et al. (1998) focus on the psychological factors at play in asset trading, specifically in overconfidence and framing effects. From a psychological point of view, Minsky (1992) has argued that when investors agree on forecasts—that is they share similar expectations—it leads to increased optimism, which drives up borrowing. In other words, agreement in expectations leads to more severe bubbles. Within our setup we can analyze the impact of conformity and confidence in an experimental asset market, as well as the behavior of heterogeneous agents—in terms of expectations.

1.3 Hypotheses

The following hypotheses guide the experimental design and our analysis.

We first hypothesize that as traders successfully predict the sign and the magniture of the price movement, they will be more confident in the next period. This hypothesis follows from the theoretical literature of trader behavior in asset markets (See for example Scheinkman and Xiong (2003), Harrison and Kreps (1978)).

Hypothesis 1. *Traders who predict the right sign of the price movement will be more certain about their predictions in the following period. This effect increases as the difference between the predicted price and the realized price grows smaller.*

A well-known result is that bubbles disappear as traders participate repeatdly in different markets. This implies that equilibrium prices follow closely the fundamental value. A typical interpretation is that markets converge to the full information rational expectations equilibrium[2] Palan (2013). A potential

[2]A notable exception is Hussam et al. (2008) where the authors show that bubbles can be rekindled by changing the fundamental parameters of the market. Hussam et al. (2008) argue that this corresponds to e.g.(unexpected) technological changes.

explanation for this is that agents' expectations align over time, which we investigate with the second hypothesis

Hypothesis 2. *Traders' expectations converge further as they participate in more markets.*

Related to 2 we examine the Minsky hypothesis of financial instability (Minsky (1992)). In very general terms, Minsky (1992) argues that success in the market leads to reckless behavior. Moreover, markets tend to aggregate information in a way that the optimism of a given trader reinforces the optimism of other traders. In terms of the experiment, this suggests that a relatively higher level of initial agreement leads to a larger bubble.

Hypothesis 3. *Increased agreement in traders' expectations leads to increased bubble tendencies* ceteris paribus.

Previously, Haruvy et al. (2007), have found that the mean of traders' expectations adds predictive power in understanding price movements. Our experimental design allows us to analyze the effect of certainty about future movements in the market. The second hypothesis deals with whether additional information on traders' confidence has additional explanatory power in predicting price movements.

Hypothesis 4. *Information on traders' confidence provides additional predictive power on price movement above and beyond: (1) the difference between the current price and the fundamental value; (2) the prior price history; and (3) the mean expectation.*

1.4 Experimental Design

Our experimental design follows Haruvy et al. (2007), though it differs in two crucial aspects: (i) we elicit confidence in forecasts; (ii) the payment is based on either forecast performance *or* trade performance. We discuss both changes below.

In each session 12 traders are grouped together (Haruvy et al. (2007) use 9 traders). They participate in two or three sequential *markets*, each consisting of 15 or 12 trading periods, respectively. Each markets has two stock valuables: an asset, denominated in *shares*, and money, denominated in *points*. Within a market, the holdings of shares and points is transferred from one period to the next. Each trader is given an endowment of shares and money at the beginning of each market.[3] In each period, the asset pays an IID ran-

[3]Denote an initial endowment of f Points and a shares of the assets by (f, a). Then four participants are endowed with $(112, 3)$, other four participants are endowed with $(292, 2)$, and the remaining participants are endowed with $(472, 1)$. Thus, a total of 24 share of the asset and 3504 Points in the first round, and up to 14304 Points in the last round.

dom dividend in points from a known and fixed distribution. The timing of a given period t is summarized in Table 1.1. Participants have two tasks: trade and predict. Traders can buy and sell shares in each period. Based on the orders, an equilibrium price is computed. In addition, at the beginning of each period, subjects are requested to forecast the equilibrium price. We elicit an approximation of the trader's distribution of beliefs as described in section 1.4.2. Traders are rewarded according to either the accuracy of their forecast or according to how much money they have accumulated. The reward is determined individually at the end of each market and transformed into Euros at a rate of 85 points per euro.

Table 1.1 – Summary of the timing of round t, where T is the total number of rounds.

Start of period t	Traders predict the equilibrium prices
	Traders make buy and sell orders.
	The equilibrium price is calculated and trade is conducted.
	The asset dividend is drawn and added to cash-holdings.
End of period t	Forecast earnings are computed based on accuracy of forecasts.

The experiment was conducted at the Behavioral Sciences Laboratory at Universitat Pompeu Fabra, Barcelona (BESLab) and utilized the software packages from Chen et al. (2014) and Bostock et al. (2011). Subjects were typically bachelor students from a wide range of disciplines with no prior experience with experimental asset markets. Each session lasted for approximately 2½ hours, of which 45 minutes was instructions. [4] Before being able to start the experiment, each trader had to complete an interactive test that demonstrated understanding of the basic mechanisms of the experiment. The average earnings per trader were approximately €25.

Below we describe the setup in greater details.

1.4.1 The asset market

The asset pays a dividend at the end of each period for each share. The dividend is drawn from the set $\{0, 4, 14, 30\}$ with equal probability. It is common knowledge that the expected dividend is 12 points. Likewise, it is common knowledge that the "fundamental value" of a share of the asset in the beginning of period $t \in \{1, \dots, 15\}$ is $f(t) = 12(15 - t + 1)$.

In each period, traders can buy and sell the asset, subject to the "no borrowing" constraint via a call market. As in Haruvy et al. (2007) the price is determined by call-market rules to ease the task of predicting future prices, as the more commonly employed double auction rules can lead to multiple prices. In each

[4] The instructions are available in in English in Appendix A.2, and in Spanish at http://pank.eu/experiment/introduction.html

period, each trader submits a buy order and a sell order. An order consists of a price p and a quantity x. A buy order specifies the maximum quantity x_b of shares that the trader is willing to purchase at a price lower or equal to p_b. Likewise, a sell order specifies the maximum quantity x_s of shares that the participant would offer if the price is at least p_s. All bids and asks are aggregated into demand and supply curves, respectively, and the equilibrium price p^* is determined.

The equilibrium price algorithm is designed to maximize trade volume, given sell and buy bids. If there is no intersection between the supply and demand curve, the equilibrium price is set to the one plus the highest offer, i.e. $p^* = 1 + \max_i \{p_{si}\}$.[5] If there is a unique volume-maximizing price, then this is the equilibrium price. Otherwise we check for prices that make the difference between supply and demand zero within the set of volume-maximizing prices. If no such price exists we check whether all prices lead to excess supply or demand and take the maximum or minimum price, respectively. Finally, if the price has not been found in any other way, we set it to the maximum price that minimizes the difference between supply and demand.

Participants who submitted buy order with $p_b \geq p^*$ will purchase assets from participants with sale offers satisfying $p_s < p^*$. If demand exceeds supply at the margin, realized trades at the margin are randomized.

1.4.2 Eliciting traders' beliefs

The main methodological contribution of this paper is that we elicit trader's entire distribution of beliefs using a elicitation tool similar to the one proposed by Harrison et al. (2012). The traders participating in the Haruvy et al. (2007) experiment are not able to express the degree of confidence in their forecasts or put weight on two disjoint distributions. The latter may be particularly relevant when forecasting the burst of a bubble; some weight may be allocated to the bubble price and some weight on the fundamental price. In our experiment participants can express a good approximation of their entire belief structure.

Our elicitation tool is a discretized version of the tool found in Harrison et al. (2012). The tool is displayed in Figure1.1. Subjects are shown a grid of price-percentage combination and are asked to predict the price in next period. To do so, participants are endowed with 20 tokens -each representing 5% confidence, that they need to assign to different Price ranges. Prices are binned in intervals of 10 along the x-axis. Along the y-axis traders are shown bins of 5% intervals. By clicking on a particular box, subjects allocate their tokens. Participants are not allowed to continue unless they assign all their 20 tokens.

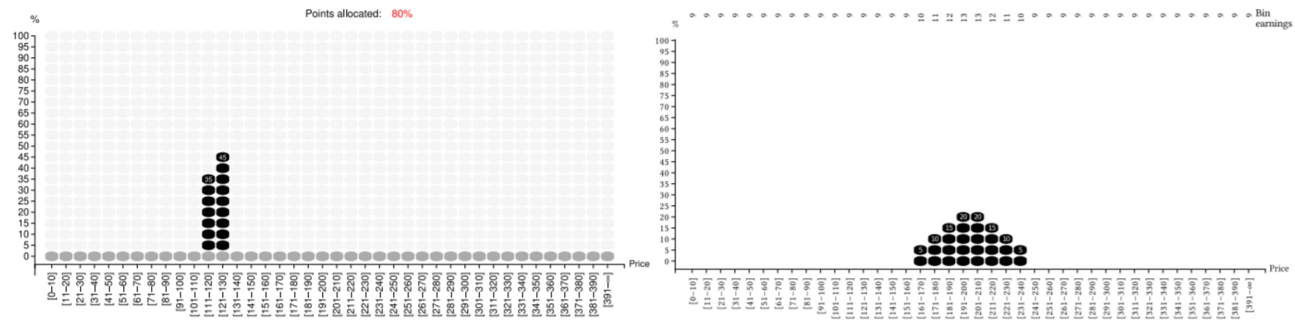
Participants are then rewarded in accordance to the accuracy of their forecasts. However, ensuring that expectations are correctly elicited is a difficult task. We

[5] This was the approach taken in the Haruvy et al. (2007) experiment.

Figure 1.1 – An example of a constructed forecast of prices in a given period

(a) Before the forecast is finalized.

(b) A finalized forecast.



will first describe the elicitation process and then discuss how we circumvent the main issues.

The price range is partitioned in $k = 1, \ldots, K$ bins. The maximum price was set such that the maximum price observed in the literature was no binding. An example of a constructed probability mass function is shown in Figure 1.1.[6]

We denote the beliefs -tokens- in a particular price interval k at a particular period τ as $s_{\tau k}$. Participants are asked to choose beliefs for every remaining period in each one of the k bins, thus assigning probabilities to each future potential price. A full report consist of beliefs allocations for each interval $s_{\tau k} = (s_{\tau 1}, s_{\tau 2}, \ldots, s_{\tau K})_{\tau=t}^{j=T}$. In this way we can elicit confidence from the forecast as in Harrison et al. (2012). Our setup requires participants to assign zero probability to some bins and allows for arbitrary probability distributions of forecasts, which may even be disjoint. This is important because participants may want to bet for two different equilibrium prices. To see this, consider the case where the forecaster expects that a bubble continues for one more period with probability q and a that the bubble burst and the market crashes with probability of $1 - q$. This gives rise to a bimodal prediction of the future price given the fact that some subjects may put some weight on the fundamental value and some other weight on the bubble value.

The difference between our baseline treatment and Haruvy et al. (2007) is that we explicitly elicit confidence. To incentivize careful predictions of the confidence levels we make payoff of the prediction contingent on the accuracy of forecasts. Scoring rules are procedures that convert a "report" by a participant in a lottery over the outcome of some event. These rules are a way of translating reported beliefs into earnings based on the actual outcome. Payoff from forecasting will follow tje Quadratic Scoring Rule (QSR),

$$S = \kappa \left[\alpha + \beta \left(2 \times r_k - \sum_{i=1}^{K} r_i^2 \right) \right], \tag{1.1}$$

[6] An example of the actual software implementation used in the experiment may be found at http://pank.eu/experimenth/ist2.html.

following (1.1) Harrison et al. (2012). This reward score doubles the report allocated to the true interval and penalizes depending on how these reports are spread across the K intervals. α, β and κ are calibrated constants. In particular, participants are rewarded, primarily according to whether the realized price is within the correct band and secondarily according to the precision of this band. The main difference between (1.1) and the Haruvy et al. (2007) setup, is that here the confidence band is determined by the participant. This scoring rule has several desirable properties which are discussed in the next subsection.

1.4.3 Risk, Ambiguity and Hedging

There are two main issues to account for when eliciting beliefs. First, the possibility of hedging. Second, the interconnection in reported beliefs between ambiguity, risk aversion and confidence.

Hedging refers to the fact that, for example, subjects may trade at optimistic values and forecast at pessimistic values in order to ensure a less variable payoff. We follow Blanco et al. (2010) and randomize which payoff is given to the agent at the end of each market.[7] In other words, participants are randomly rewarded either according to the accuracy of their predictions, as in Haruvy et al. (2007), *or* according to their earnings in the asset market. In the initial pilot sessions payoffs were calibrated to match the same expected earnings in both types of tasks. In this way, we are able to elicit more detailed information about beliefs and confidence compared to Haruvy et al. (2007).

The risk attitudes may affect the incentive to report one's subjective probability truthfully in equation (1.1). Harrison et al. (2012), characterize the properties of the Quadratic Scoring Rule when a risk averse agent needs to report subjective distributions over continuous events. For empirically plausible levels of risk aversion it is possible to elicit reliably the most important features of the latent beliefs without undertaking calibration for risk attitudes. The qualitative effect of greater risk aversion when eliciting continuous distributions is to cause the individual to report a "flatter" distribution than the true distribution. In particular, the Scoring Rule has the following properties:

1. The individual never reports a positive probability for an event that does not have a positive subjective probability, independently of the risk attitude

2. Events with the same subjective probability have the same reported probability

3. The more risk averse the agent is, the more the reported distribution will resemble a uniform over the support of the true latent distribution

[7]Another possibility is doing "small" payments in order not to distort the incentives. However, since it is the main focus of our paper we decided for incentivizing this activity properly.

Table 1.2 – Overview of the sessions, number of markets and number of participants.

Session	Markets	Rounds	Participants	Assets
A	2	15	12	27
B	2	15	12	27
C	3	12	12	27
D	3	12	12	27
E	2	15	12	27

Moreover, participants show modest levels of risk aversion almost universally in the laboratory, for which the effect is virtually imperceptible Harrison and Rutstrom (2008). Therefore, we can use the reported distributions as if they are the true subjective belief distributions, assuming away risk. In any case, we can certainly infer a lower bound on confidence with these properties.

1.5 Overview of experimental data

In this section we show the basic properties of the data from our study conducted at the BESlab, Universitat Pompeu Fabra, Barcelona. A total of five sessions was conducted.[8] The summary of number of participants and markets are shown in Table 1.2. Session A, B and E had 2 markets, each with 15 rounds. Session C and D instead had 3 markets each consisting of 12 rounds. All sessions had 12 participants. Likewise, all sessions have a total of 27 tradeable assets.

1.5.1 Summary of the trade data

We first turn to the descriptive statistics of the main variables in the experiment. As argued above traders react and set the price in this experiment. The period to period development of the price for each of the sessions is shown in figure 1.2. The lines and the dots in figure 1.2 show the price movement. Curves and dots are color-coded depending on the total number of rounds per market. The gray step line shown behind the price curves display the fundamental value of an issue of the asset in that particular round. Note that sessions with 12 rounds per market have been shifted to start at period 3. This is to align the final period across graphs.

In a market with perfect foresight and fully rational players the price curve should coincide with the fundamental value curve. In addition, the graph show

[8] A couple of pilot sessions were also conducted. The data from these sessions is not used, as they either did not conclude, were conducted with fewer participants, or were conducted using a vastly different version of the experimental software.

Figure 1.2 – The development of equilibrium prices over markets and market periods. The gray step-lines display the fundamental value of the asset.

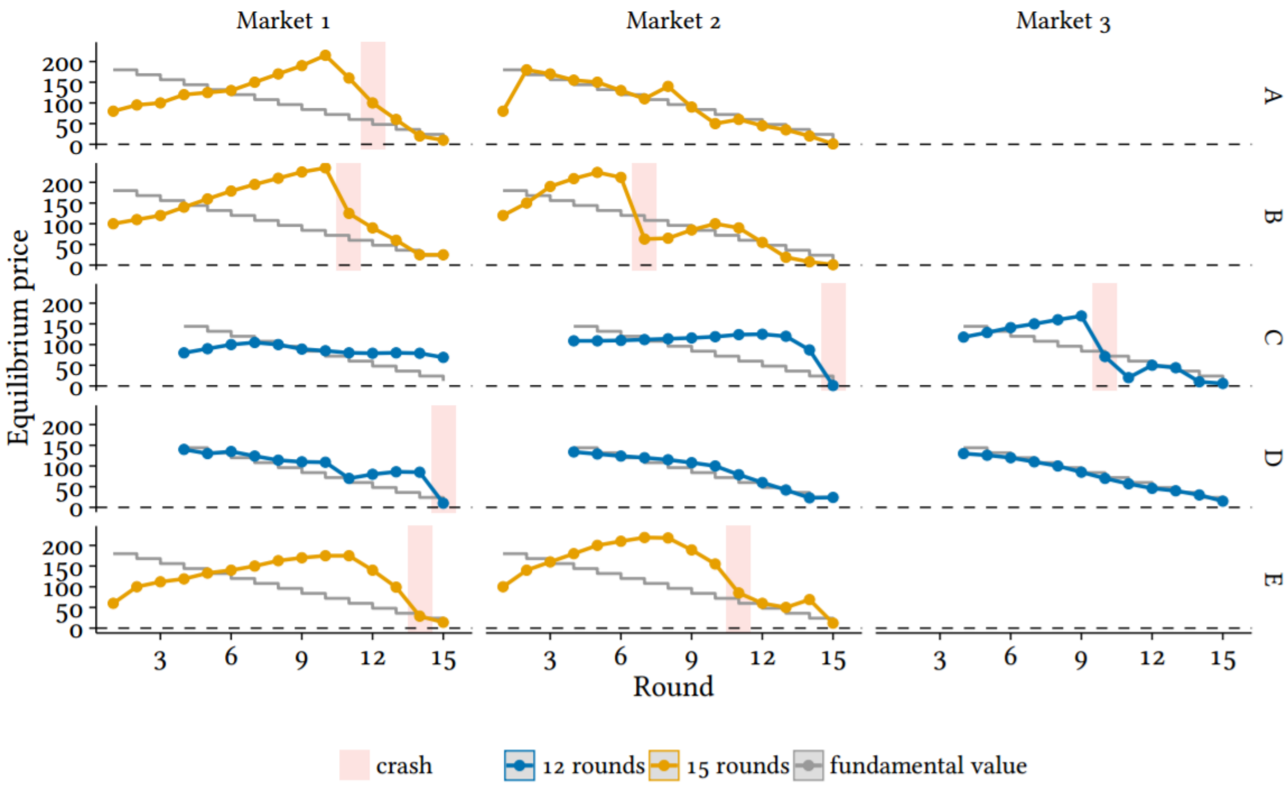


Table 1.3 – Realized price in each round per market and per session. f_t denotes the fundamental value for period t. Note that we have shifted down sessions with 12 rounds, as the fundamental value depends on the remaining number of rounds.

		Market 1					Market 2					Market 3	
t	f_t	A	B	C	D	E	A	B	C	D	E	C	D
1	180	80	100			60	80	120			100		
2	168	95	110			100	180	150			140		
3	156	100	120			112	170	190			160		
4	144	120	140	80	140	119	155	209	109	134	180	118	130
5	132	125	160	90	130	133	150	224	109	129	200	129	126
6	120	130	179	100	135	140	130	212	110	124	210	141	120
7	108	150	195	105	124	150	110	63	112	120	219	150	110
8	96	170	210	100	114	163	140	65	114	115	218	160	100
9	84	190	225	89	110	170	90	85	116	108	189	169	85
10	72	215	235	85	109	175	50	100	119	100	155	71	70
11	60	160	125	80	70	175	60	90	124	79	85	20	57
12	48	100	90	79	80	140	45	55	125	60	60	50	46
13	36	60	60	80	86	99	35	19	120	42	50	44	40
14	24	20	25	79	85	29	20	8	87	23	69	10	30
15	12	10	25	69	10	14	1	1	1	24	12	6	15

periods where the price "crashes", corresponding to a fall in price of more than 60 points. The exact prices may be found in Table 1.3b where the fundamental value is also shown. The price movements display similar trends to those found in similar experiments, such as Haruvy et al. (2007). The- peak price typically occur around period 10–11 in the sessions with 15 rounds. As can be seen from the graph, the markets clearly exhibit bubble tendencies, as is found in most similar experiments. Since the experiment is already long, we have limited out the sessions with 15 periods to two markets. In our second market bubbles still occur in session 2, though less so than in the first market. This indicates a similar learning process to the one described in Haruvy et al. (2007), so we conclude that the proposed elicitation does not affect behavior.

There is a fair bit of variation between sessions. While the three sessions of 15 rounds, session A, B, and E, show a typical hump shape known from this type of asset market experiments, the two sessions with 12 rounds, session C and D, show a less characteristic shape. Session D seems to almost converge to the fundamental value within the first market, and completely converges in the second market and the third market. Across sessions, the market crash tends to be in a later round in the first market, compared to market crashes in subsequent markets.

In each round, traders put forward a bid-quantity tuple and a ask-quantity

Table 1.4 – Realized trade per round per market and per session.

	Market 1					Market 2					Market 3	
Round	A	B	C	D	E	A	B	C	D	E	C	D
1	4	2			5	2	1			5		
2	5	3			4	1	4			4		
3	1	3			6	2	4			3		
4	2	5	5	5	2	2	4	5	5	3	4	6
5	8	3	6	3	4	3	7	4	2	6	2	4
6	5	4	6	3	6	2	3	2	5	5	4	4
7	2	5	3	4	9	2	2	2	2	3	3	2
8	1	4	7	4	4	2	8	3	3	2	4	2
9	4	3	3	8	6	1	1	4	6	4	1	4
10	3	2	3	5	4	1	7	3	5	3	0	3
11	2	3	6	4	6	2	1	2	2	2	7	3
12	2	4	4	5	2	4	2	6	3	9	4	2
13	8	5	3	2	4	5	5	2	5	5	3	3
14	2	3	4	1	1	2	4	0	4	1	1	7
15	8	13	4	5	12	6	5	1	1	5	0	4

tuple. Recall that bids are the maximum price that a trader is willing to buy at while a ask is the minimum price a seller is willing to sell at. Based on this, an equilibrium price is computed in each round using the mechanism described in the previous sections and the realized prices shown in Table 1.3. In addition to the prices, the realized traded quantities are shown in Table 1.4. The number of traded assets are not shown to participants during the experiment. For sessions with 12 rounds per market the 12th and last round has been aligned with the last round in the sessions with 15 rounds. As the table show, there is level of realized trade is generally above zero, with a few exceptions in session C.

The raw bid and ask data used to calculate the equilibrium price is shown below in Figure 1.3. The graph shows the demand and supply at each potential price as well as the realized price. A large point indicates a larger bid/ask at that point. Based on the pricing mechanism and the raw bids and asks, the equilibrium price is determined.

1.5.2 Market characteristics

In Table 1.5 we display summary statistics of each market as well as the. In parentheses we show standard deviations between markets. These values correspond to values in the market, further suggesting that the treatment is neutral.

Figure 1.3 – Supply and demand in per session, market and round.

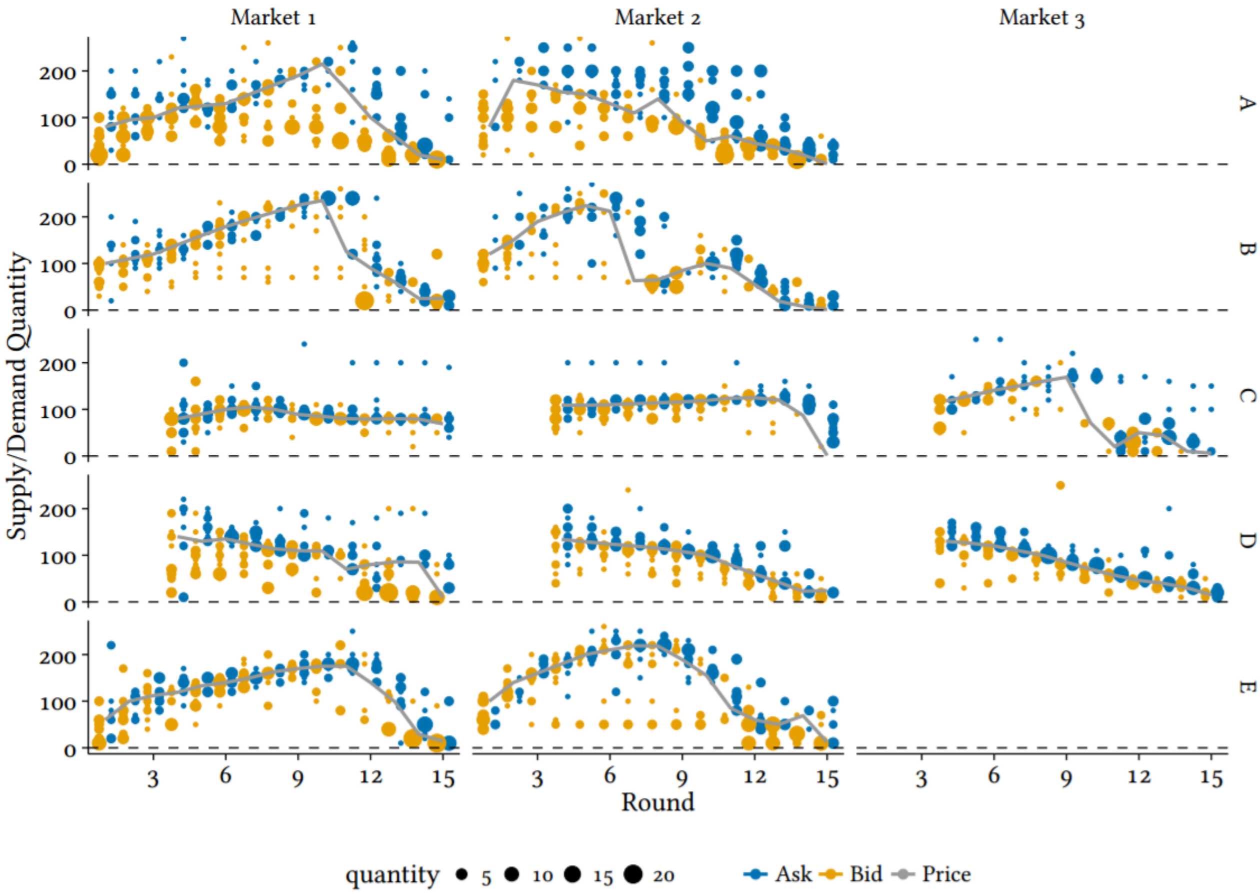
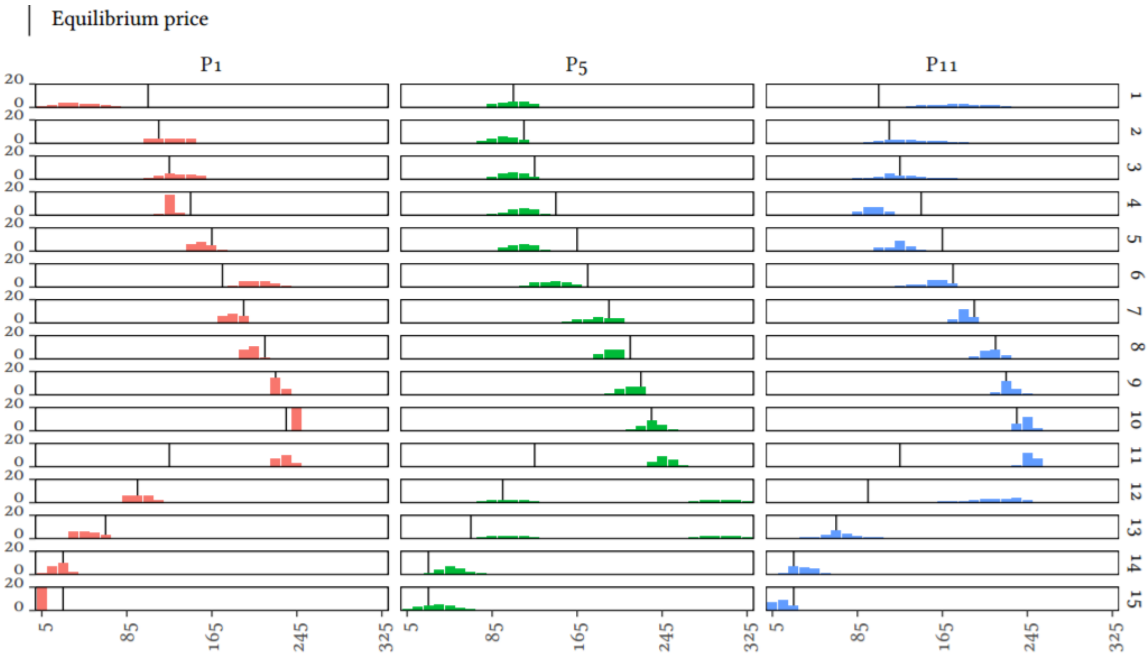


Table 1.5 – Summary statitics describing each market. The values in parentheses are standard deviation between markets.

	Market 1					Market 2					Market 3	
	A	B	C	D	E	A	B	C	D	E	C	D
Peak price	215	235	105	140	175	180	224	125	134	219	169	130
Peak period	10	10	4	1	11	2	5	9	1	7	6	1
Total trade	57	62	54	49	75	37	58	34	43	60	33	44
Trade to peak	35	34	20	5	56	3	20	31	5	29	18	6
Trade post peak	22	28	34	44	19	34	38	3	38	31	15	38
Turnover	2.1	2.3	2.0	1.8	2.8	1.4	2.1	1.3	1.6	2.2	1.2	1.6
Amplitude	2.5	2.7	5.2	2.7	2.6	1.4	1.7	3.5	1.1	2.3	1.7	0.3
Normalized deviation	92.8	114.0	59.5	36.0	149.6	20.3	82.6	51.4	20.8	111.4	36.6	7.7
Boom duration	8	11	8	9	11	8	4	8	8	12	4	3
Bust duration	5	4	4	2	4	4	3	3	2	2	2	3
Total dispersion	817	915	358	273	853	258	547	468	150	823	312	47
Average bias	19.0	37.3	8.3	21.4	22.6	-1.6	10.1	25.8	10.2	40.5	11.0	-0.6
Upward trend	9	9	3	2	9	1	4	7	1	6	5	0

Figure 1.4 – An example of realized one period ahead price forecasts from the experiment. Each column display the a particular trader's forecast for each of the 15 rounds in the market. Realized prices as well as the traders' maximum buy price and minimum sell price is also shown.



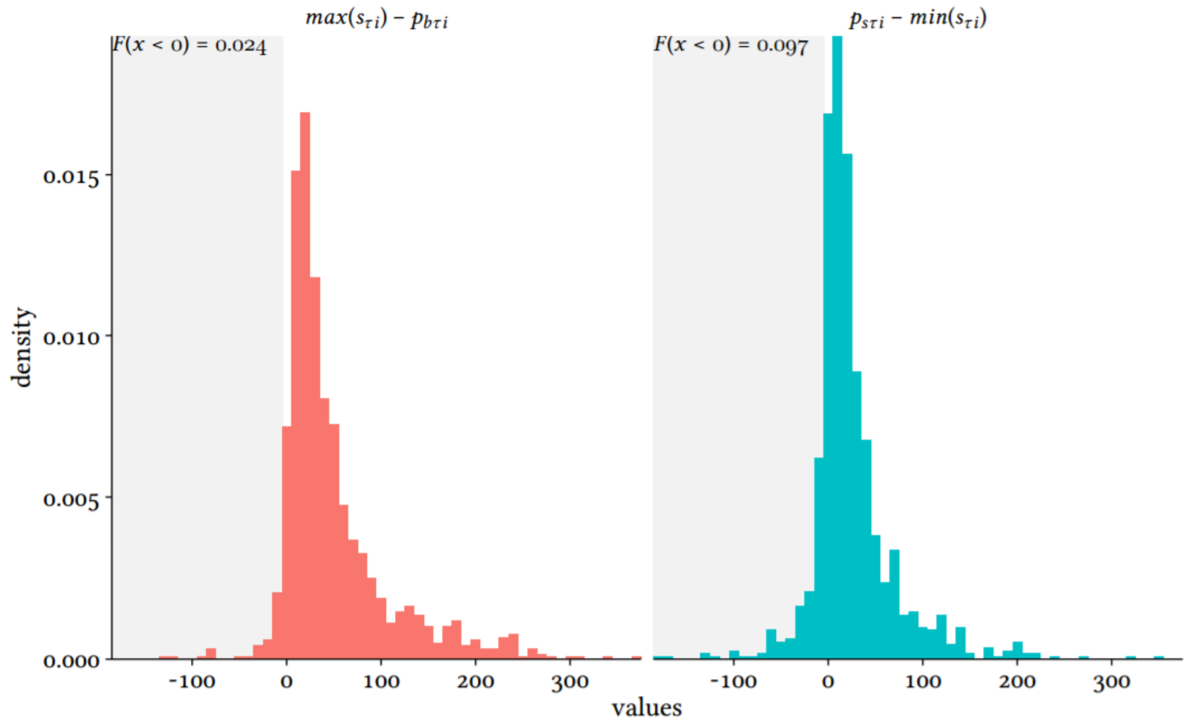
1.5.3 Expectation data

The main difference in this experiment compared to the previous literature is the way forecasts are elicited. As discussed above, participants forecast the price development in the beginning of each round using the tool shown in Figure 1.1. Some examples of the forecasts that subjects produced are shown in Figure 1.4. The figure shows forecasts conducted by three different participants in a particular market. These participants are P1, P5, and P11[9]. In the top line the traders' first round predictions are shown, and in the bottom line their final predictions are shown. Each of the small graphs show price bins on the x-axis and the number of points (out of 20, or 5%) allocated to the bins on the y-axis. For instance, we see that P1 has allocated all 20 points to a single bin in round 10. The graph also shows the realized equilibrium price with the vertical, brown line. In this market a crash occurs in the 11th period.

Wider distributions, such as the ones seen in the first period, suggest that the trader is more uncertain about future price. Traders tend to make tighter distributions, concentrating on only a few potential prices, before period 11 – the crash. Note that each of the three traders behave differently after the crash. P1 immediately switches to the new equilibrium price trajectory. P5 uses a bimodal distribution that putting some weight on the return to the bubble price and some weight on the fundamental value. P11 assumes the crash

[9]While we only show 3 traders here, the data provides the full set of expectations for each participant for each round.

Figure 1.5 – The distributions of difference between bids $p_{b\tau}$ and asks $p_{s\tau}$ and forecasts $s_{i\tau}$ over all traders i and periods τ.



was a temporary shock, and expects the prices will return to previous levels –although with less confidence, as evidenced by the variance of the forecast.

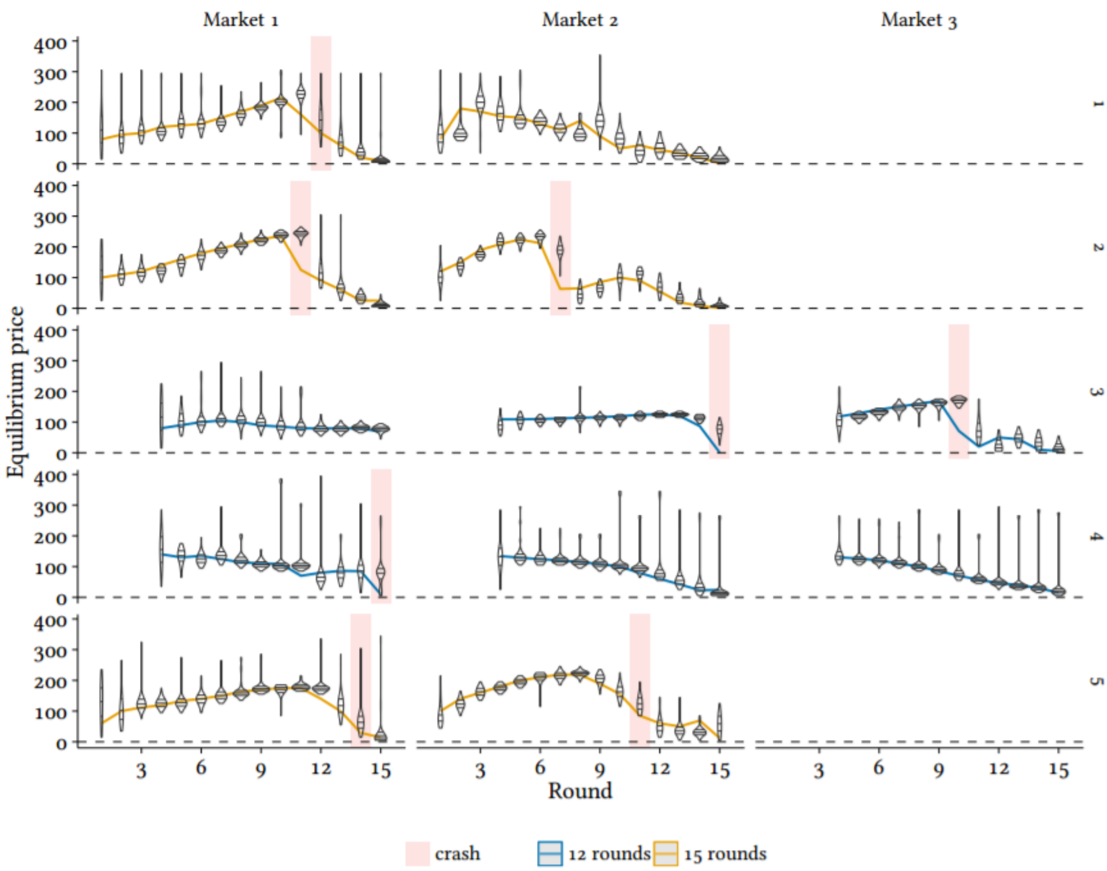
A simple check to verify that the participants understood the game and acted rationally, is to analyze whether forecasts are in line with their bids and asks. For instance, if a trader expects prices to be between 100 and 140 he should not offer to buy shares at a price above 140. Figure 1.5 shows the density of the difference between the maximum forecast and the bid on the left, and the difference between the ask and the minimum forecast on the right, over all rounds τ and all traders i. If traders are rational, they should not bid at a price above their expectations. [10]

If all traders acted rationally, there should be no support for negative values in the distribution of $\max(s_{\tau i})p_{b\tau i}$ shown in Figure 1.5. As the graph shows, most of the support is on positive numbers, suggesting that traders mostly understand the tasks. Only 2.4% of the bids are incompatible with their forecasts, in the sense that people are willing to buy at higher prices than what they expect. The graph also shows that 9.7% of the asks are lower than the minimum price the trader expects. This is, however, less of a concern, as the ask price only reflects the lowest price they are willing to accept.

Finally, Figure 1.6 shows the market sentiment and equilibrium prices. The

[10]We cannot make an equally strong statement for asks, as the optimal ask strategy depends on trader i expectations about all other traders beliefs.

Figure 1.6 – Price expectations and realized prices. The line show the development of the price. The violin distributions show the expectations of all participants, including the upper and the lower quartile as well as the median, as shown by the horizontal lines within the violin distributions.



market sentiment is displayed using a violin plot where the width of the violin show the mass at a given price. Here, the market expectation is simply the union of all forecasts by all traders, treated as if they were all a single distribution.

Some patterns are clear across sessions. In general, market expectations are more dispersed in the first round, as shown by the wider range between the upper and the lower quartile. This also seems to be the case across sessions. However, the expectations in the first round of the second market tend to be more certain than in the first market. This can be seen across all sessions. In the interim periods between the beginning and the crash, market expectations tend to become more certain, a measured by a smaller distance between the upper quartile and the lower quartile. We see this, for example, in the first market of session A and B,. Crashes are not widely expected, and the realized price in a crash tends to be lower than the lower quartile of expectations. This is the case for all the crashes observed in the data. Interestingly, the standard deviation market expectations is sometimes increasing ahead of a crash - for instance in Session E-. At other times, the crash is completely unexpected, as is the case of session B.

1.6 Results

1.6.1 Predictions and forecast

We now turn attention to Hypothesis 1. This hypothesis states that we expect traders to narrow their beliefs as their beliefs are reinforced. In other words, if traders experience that their predictions are correct, they will become more certain, as expressed by a tighter belief distribution. A longer strike of correct predictions for traders can itself lead to a longer bubble, under this hypothesis. Potentially, narrower beliefs, expressed through tighter forecasts distributions, would lead to longer bubbles — essentially as traders are *riding the bubble.*

To investigate the claim, we look at whether increased success lead to a tighter forecast distribution. We expect that if a trader had a high degree of success in his forecast in period $t-1$, as measured by their forecast scoring, S_{t-1}, he will be more likely to predict a tighter distribution, i.e. a distribution with a smaller σ. We can express this using the following equation,

$$\sigma_{it} = \beta S_{it-1} + \alpha' \lambda + \epsilon_{ti}. \tag{1.2}$$

Here, λ represents a set of dummy variables such as the trader ID, the round number, and market and session numbers. If traders become more confident as they make correct predictions the sign on β should be negative. The result is shown in Table 1.6. The data consists of all traders who have participated in the experiment. In the first column of Table 1.6 we show the results of the regression using the lagged forecast score S_{it-1} on the standard deviation of

Table 1.6 – Regressions on traders' certainty and success in forecasting using σ as the dependent variable. As the regressions show, traders become more certain as they successfully forecast the correct movement.

	σ_{it}				
	(I)	(II)	(III)	(IV)	(V)
S_{it-1}	-0.06^{***}	-0.05^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Session FE		✓	✓	✓	✓
Participant FE			✓	✓	✓
Market FE				✓	✓
Round FE					✓
Num. obs.	1800	1800	1800	1800	1800
R^2	0.03	0.07	0.33	0.34	0.36
Adj. R^2	0.03	0.07	0.31	0.32	0.33

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Std. errors clustered on participants.

the forecast in period t. Note that the intercept included in the regression, but not shown here. In the first column we show the simplest regression of S_{it-1} on $\sigma_i t$. There's a clear and stable negative relationship between the two variables, suggesting that increased prediction success in the previous round, leads to a higher level of confidence, as measured by the width of the forecast distribution. Using the result of regression (I), a one unit increase in lagged forecast earnings lead to a 0.06 reduction of the standard deviation.

The mean standard deviation across sessions and market of σ_{ti} is 9.93, and the mean itself has a standard deviation of 6.92. For S_{it-1} the equivalent numbers are 32.22 and 12.32. The regressions displayed in Table 1.6 thus suggest that an increase in the forecast performance of one standard deviation would lead to a reduction of the standard deviation of σ_{ti} of between 0.19, in regression (I), and 0.15, in regression (V). This suggest a strong behavioral pattern that could help explain the occurrence of bubbles in the market place.

1.6.2 Convergence of expectations

We now turn to hypothesis 2. The hypothesis states that expectations among market participants increase over as they repeatedly play in the same market. It is already known that market prices tend to converge in these markets, but here we are interested in whether expectations over prices also converge over time.

If expectations converge over time, the forecast distributions become more and more alike. In other words, if the expectations of trader 1 and trader 2 converge over time, they should hold similar beliefs about the probability of

Table 1.7 – Regressions on traders' certainty and success in forecasting using the range of the forecast as dependent variable.

	range$_{it}$				
	(I)	(II)	(III)	(IV)	(V)
S_{it-1}	-0.18^{***}	-0.15^{***}	-0.14^{***}	-0.13^{***}	-0.13^{***}
	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)
Session FE		✓	✓	✓	✓
Participant FE			✓	✓	✓
Market FE				✓	✓
Round FE					✓
Num. obs.	1800	1800	1800	1800	1800
R^2	0.04	0.08	0.34	0.35	0.38
Adj. R^2	0.04	0.07	0.32	0.33	0.36

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Std. errors clustered on participants.

price p becoming the next equilibrium price.

To investigate this we measure the overlap of traders' belief distributions. To do this we use the relatively simple Bhattacharyya coefficient for discrete random variables defined as

$$BC(q_1, q_2) = \sum_{i=1}^{N} \sqrt{q_{1,i} q_{2,i}}, \tag{1.3}$$

where q_1 and q_2 are price forecast distributions from two different traders. Here, $q_{1,j}$ is the probability that the realized price falls in price bracket j in accordance with the forecast of the first trader. Note that if the two probabilities distributions assign equal mass to all brackets then $BC(p, q) = \sum_{i=1}^{K} \sqrt{q_{1,i} q_{2,i}} = \sum_{i=1}^{n} \sqrt{q_{1,i}^2} = 1$. Likewise, if the two distributions are completely disjoint such that there exists no j such that $q_{1,j} > 0$ and $q_{2,j} > 0$ then $BC(p, q) = 0$. In the latter case, the statistic does not discriminate against distributions with very different means, making the test stronger.

To test whether beliefs converge over time we calculate the BC coefficient for all pairs of traders in each round of the experiment. Thus we have 132 BC coefficients per round.

As first test to address Hypothesis 2, we check whether the observed overlap of forecasts is similar. We perform Wilcoxon signed rank sum test with a one-sided alternative hypothesis. Specifically, for market $m = 1, 2$ we compare the difference $BC_{ij}^{m} - BC_{ij}^{m+1}$ for traders i and j and test that there is no difference in the median under the null. We use a non-parametric test over a t-test as the distributions of differences between values of market 1 and market 2 have fat tails and are only spread over the domain $[-1, 1]$. Note that for the

Table 1.8 – Average overlap of distribution as measured by BC. Plain numbers denote the median while numbers in parentheses denote the standard deviation. The superscripted stars denote the significance of the p-value of the Wilcoxon Signed Rank Sum Test between the observations from period j in market i and $i-1$.

t	1		2		3	
1	0.158	(0.284)	0.450***	(0.319)		
2	0.619	(0.302)	0.701***	(0.240)		
3	0.723	(0.252)	0.790	(0.303)		
4	0.606	(0.337)	0.677***	(0.315)	0.667**	(0.311)
5	0.655	(0.318)	0.793***	(0.282)	0.875***	(0.260)
6	0.706	(0.336)	0.792***	(0.276)	0.889*	(0.266)
7	0.769	(0.345)	0.818***	(0.293)	0.835	(0.309)
8	0.736	(0.308)	0.772	(0.324)	0.874	(0.361)
9	0.772	(0.271)	0.734	(0.289)	0.837	(0.312)
10	0.802	(0.349)	0.736	(0.303)	0.763	(0.282)
11	0.790	(0.320)	0.749	(0.327)	0.737	(0.365)
12	0.602	(0.350)	0.688***	(0.315)	0.826	(0.321)
13	0.649	(0.328)	0.801***	(0.283)	0.878*	(0.285)
14	0.656	(0.330)	0.777***	(0.295)	0.819	(0.337)
15	0.725	(0.339)	0.662	(0.333)	0.767	(0.317)
All	0.706	(0.334)	0.749***	(0.306)	0.830	(0.318)

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 1.9 – Regression analysis on overlap of expectations.

	BC			
	(I)	(II)	(III)	(IV)
Market 2	0.06^{***}	0.06^{***}	0.06^{***}	0.06^{***}
	(0.01)	(0.01)	(0.01)	(0.01)
Market 3	0.11^{**}	0.07^{**}	0.07^{**}	0.07^{**}
	(0.03)	(0.02)	(0.02)	(0.02)
Session FE		✓	✓	✓
Round FE			✓	✓
Participant FE				✓
Num. obs.	21384	21384	21384	21384
R^2	0.01	0.03	0.06	0.18
Adj. R^2	0.01	0.03	0.06	0.18

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.Std. errors clustered on participants.

comparison between market 2 and 3 we are only using data from the sessions with 12 rounds per market.

In the last row of Table 1.8, denoted *All*, we show the median overlap in market 1, 2 and 3 using data from all sessions. The numbers in the parentheses are the standard deviation and the stars denote the p-value of the Wilcoxon signed rank sum test. As can be seen, the median level of overlap in forecasts is increasing over the markets. The most relevant comparison is between market 1 and market 2, as they both use the full sample of data. As the table show, the median overlap over all sessions increases by approximately 0.05 between the two markets. The exact p-value of the test is less than 0.001, and as such we strongly reject the null that the median is the same.

The upper part of Table 1.8 compares median overlap of predictions across rounds and sessions. The main difference across markets is the starting level of overlap, which increases across markets. In the sample, the median overlap of expectations in the first round is 0.158 in the first market, 0.450 in the second market and 0.667 in the third market.

Table 1.9 show a regression analysis of the data. The dependent variable is BC_{ij} and we control the regressions with a As the table shows, the overlap measure increases by 0.06 from market 1 to 2, and approximately the same from market 2 to 3, although the significance of the latter is decreasing. Note that in column (IV) we control for participant, session and round.

In summary, the data supports the hypothesis that expectations are converging across markets.

1.6.3 Market volatility and initial expectations

We now turn to the related questions of whether initial disagreement in forecasts lead to smaller bubbles, as proposed by Hypothesis 3. The hypothesis states that if traders agree more this increases the likelihood of them "riding the bubble". If this is the case, an initial level of agreement in the market would lead to a larger bubble. A potential explanation would be that people form wrong expectations about the equilibrium price-path, disregarding the fundamental value. Alternatively, people could be betting on riding the leaving and leaving it in time before it bursts.

To investigate Hypothesis 3 we use market level variables. This allow us to take a broad approach to problem. However, it also implies few degrees of freedom. We use the two bubble measures introduced in Stöckl et al. (2010) and used in Kirchler et al. (2012). These measures are the measure for relative absolute deviation (RAD) and relative deviation (RD), also shown in Table 1.5. We use these measures as they are insensitive to the choice of parameters, such as the numbers of round (Stöckl et al. (2010)). Due to the particular way our sessions were conducted this is a necessary property for our experiment.

RAD and RD measures are defined as,

$$RAD = \tfrac{1}{N}\sum_{t=1}^{T}\frac{|p_t - f_t}{|}|\bar{f}_t| \tag{1.4}$$

$$RD = \tfrac{1}{N}\sum_{t=1}^{T}\frac{p_t - f_t}{\bar{f}_t} \tag{1.5}$$

Both measures compare the realized price p_t to the fundamental value f_t. As it is summed over all periods, both the duration of the bubble and the magnitude of the bubble have the potential to lead to a larger a value of the measures. As we divide by the average value of the fundamental, $\bar{f}_t$, the values are scaled to make the sessions with different duration of markets comparable. RAD measures the average level of mispricing, be it a bubble or a burst. This means that it is able to capture both the undervaluation in initial periods as well as the overvaluation as p_t exceeds f_t. RAD is similar to the amplitude measure, as it measures overall deviation. RD does not use the absolute value, and as such positive and negative values can offset each other.[11]

As our " variable we use the BC measure introduced above, in Equation (1.3). As the analysis is conducted on a market level, we use the average value over the first τ periods $\overline{BC}_\tau = \frac{1}{\tau}\sum_{t=1}^{\tau}\frac{1}{N(N-1)}\sum_{i,j} BC_{ij,t}$, where i and j are traders and N is the number of participants.[12] As shown above, the measure $\overline{BC}$ increases over the number of markets that traders have participated in, and as

[11]Note that all markets except market 2 in session A and market 3 in session D featured positive relative deviations.

[12]We also vary τ as a robustness-check.

Table 1.10 – Results of Regression (1.6).

	RAD			*RD*		
	(I)	(II)	(III)	(IV)	(V)	(VI)
(Intercept)	0.46			0.17		
	(0.32)			(0.21)		
$\overline{BC}_\tau$	-0.12	1.44^{**}	1.33^{*}	0.04	1.00^{**}	1.56^{*}
	(0.59)	(0.40)	(0.37)	(0.41)	(0.23)	(0.51)
Market FE		✓	✓		✓	✓
Session FE			✓			✓
Num. obs.	12	12	12	12	12	12
R^2 (full model)	0.01	0.67	0.96	0.00	0.49	0.86
Adj. R^2 (full model)	-0.09	0.55	0.88	-0.10	0.29	0.61

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Std. errors clustered on markets.

such it is necessary to control for the level of experience. We use fixed effects for the market and the sessions to control for this.

As such the regression is,

$$y_{s,m} = \beta \overline{BC}_\tau + \lambda_m + \lambda_s \tag{1.6}$$

where the depend variable $y_{s,m}$ is the bubble size variable (i.e, *RAD* or *RD*), and λ_m and λ_s are market and session fixed effects respectively. The results are shown in table 1.10 where we used $\overline{BC}_2$ for session C and D (with 12 rounds) and $\overline{BC}_3$ for session A, B and E (with 15 rounds). We vary τ as we want to keep the fraction of rounds considered for forming the initial BC similar.

Even though the results are not statistically strong due to the low number of observations, we find support for the hypothesis that more disagreement dampens the size of the bubble. A large *BC* means a large overlap on traders expectations, and this implies a larger bubble coefficient. This provides support for the Minsky hypothesis, in the sense that more stable expectations tend to cause bigger market crashes.

1.6.4 Explanatory power of confidence on price formation

We now turn to the Hypothesis 4 of whether prediction of the price changes can be addressed more adequatly using trader certainty. In other words, we want to examine to what extent the distributional beliefs of traders can be used to understand and predict price movement in the experimental market.

This can be examined using the following regression,

$$\Delta p_{m,t} = \beta_0+\beta_1(p_{m,t-1}-f_{t-1})+\beta_2\Delta p_{m,t-1}+\beta_3 T_{m,t}+\beta_4\Delta E_{m,t}+\beta_5(p_{m,t-1}-E_{t-1})+\beta_6\sigma^m_{m,t}+\epsilon_{m,t}. \tag{1.7}$$

This regression models the relationship between the change in the price and various regressors that affect the price. The first term, $p_{m,t-1} - f_{t-1}$, known as the lagged bias, shows the difference between the realized price and the fundamental value of the asset in the previous period. The second term, $\Delta p_{m,t-1}$ shows the lagged differenced price. The third term, $T_{m,t}$ corresponds to the number of short term pessimistic traders, as defined by Haruvy et al. (2007).[13] They show that the number of pessimistic traders is an effective measure to predict the change in prices, and as such it can be seen as a measure of market sentiment. In addition to these terms, we add three terms that measure further aspects of market sentiment.

First, we use the change of the mean expectation from last period to this, $\Delta E_{m,t}$. This measures the change the first moment of expectations. Second, we use the lagged difference between the realized price and the expectation, $(p_{m,t-1} - E_{t-1})$. This works as an error correction term that measures the mistake in traders' expectation in the last period. Finally, we add the standard variation of expectations in the current period.

To calculate the previous variables, we use two measures of market confidence: at the individual level (σ_t) and at the market level (σ^m_t). For the individual level, the summary statistic can be calculated for each subject and summarized to a single measure of confidence for each period. For the aggregate level we create a *market sentiment* variable, $\sigma_{m,t}$. We combine the forecasts of all traders before calculating the statistics. In particular, we create a new forecast pmf containing all forecasts from all traders and calculate the statistics based on this forecast. We interpret this as "market sentiment."

To illustrate, consider a market with two traders, where the each trader creates a forecast distribution consisting of three points. If the first trader makes the prediction $\{1/3, 1/3, 1/3\}$ (that is the trader believe that the price will be either p_1, p_2 or p_3 with $\frac{1}{3}$ chance, and the second trader makes the prediction $\{1/2, 1/4, 1/4\}$ we calculate the statistics on the pmf $\{5/12, 14/24, 14/24\}$. This approach only makes a difference for non-linear statistics such as the variation. For most of the variables, this has little impact. Likewise, one can use the median rather than the mean in (1.7).[14]

A set of results using Regression (1.7) and the augmentation factors are shown in Table 1.11. All regressions are on the change in price Δp_t as dependent variable. From left to right, each column displays a more complex model. The first regression, (I) shows that both the magnitude of the change in the previous round, Δp_{t-1}, and the realized necessary correction to the fundamental value, $p_{t-1} - f_{t-1}$ are significant. While the coefficient on Δp_{t-1} becomes insignificant

[13] The relative number of traders for whom the median forecast in period t is lower than the median of the foreast in period $t - 1$.

[14] This does not markedly alter the results.

Table 1.11 – Regression results of (1.7). Normal standard errors are used. Note that the coefficient on the intercept is omitted.

	Δp_t						
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Δp_{t-1}	0.34^{***}	0.00	0.31^{***}	-0.43^{*}	-0.42^{*}	-0.37	-0.42
	(0.07)	(0.10)	(0.07)	(0.21)	(0.20)	(0.19)	(0.22)
$p_{t-1} - f_{t-1}$	-0.28^{***}	-0.31^{***}	-0.29^{***}	-0.26^{***}	-0.28^{***}	-0.22^{***}	-0.27^{***}
	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.06)
T_t		-34.19^{***}			-25.37^{**}	-11.85	-8.52
		(7.08)			(7.65)	(7.87)	(8.88)
σ_t^m			-0.26^{*}	-0.30^{**}	-0.20	-0.42^{***}	-0.62^{***}
			(0.11)	(0.11)	(0.11)	(0.11)	(0.14)
ΔE_t				0.75^{***}	0.50^{*}	1.25^{***}	1.49^{***}
				(0.20)	(0.21)	(0.26)	(0.28)
$E_{t-1} - p_{t-1}$						-0.93^{***}	-1.09^{***}
						(0.22)	(0.24)
Session FE							✓
Market FE							✓
Round FE							✓
Num. obs.	138	138	138	138	138	138	138
R^2	0.29	0.39	0.32	0.38	0.43	0.50	0.61
Adj. R^2	0.28	0.38	0.30	0.36	0.40	0.47	0.53

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

and even changes sign as more variables are added, the coefficient on $p_{t-1} - f_{t-1}$ remains negative and of approximately the same magnitude throughout all regressions. This suggests that as the difference between the equilibrium price and the fundamental value of grows larger, the change in price is dampened. In other words, the fundamental price does play a role in how the market moves as a whole.

For regression (ii) we compute the relative number of short term pessimists, T_t. Note that regression (ii) is identical to the regression used by Haruvy et al. (2007). This measure, is defined as the relative number of traders for whom their median forecast in period t is lower than the median of the forecast in period $t-1$.[15]

In Haruvy et al. (2007) the distribution of beliefs by participants is symmetric and as such the mean and the median coincide. The results shown in Table 1.11 do not change when we use the mean of the forecasts rather than the median to define T_t. Nor does it change when we require both the mean and the median of round t to be lower than those of round $t-1$.

In regression (iii) we add σ_t^m, the standard variation of the market forecast, which we denote *market uncertainty*. The coefficient is negative and significantly different from zero across specifications (iii)–(vii). The fact that the coefficient is negative suggests that a larger spread of the forecast distribution leads to less price movement. In other words, as market uncertainty about the prices moment increases, the price movement in dampened. As more controls are added in regression (vi) and (vii), the effect of market uncertainty on price movement increases.

In Regression (iv) and (V) we include measures of the two first moments of expectations. Regression (V) also includes the T_t measure. Note that the inclusion of T_t in regression leads to an insignificant coefficient on σ_t. However, once we include additional market sentiment measures, namely the correction factor $E_{t-1} - p_{t-1}$, and the change in the mean expectation ΔE_{t-1}, the coefficient on σ_t^m is significant again, as shown in regression (vi).

Regression (vi) shows a strong coefficient on $E_{t-1} - p_{t-1}$, implying that traders correct their beliefs when their previous expectation differs from the realized price. Likewise, the change in the first moment of the expectation, ΔE_t, follows the same sign as the change in price, indicating that traders are usually capable of predicting the direction of the price movement. In the final regression, (vii) we add a number of fixed effects to control for to the particular session, market or the number of round. Adding the fixed effect does not alter the results.

Note that if we let $\beta_4 = \beta_5 = \beta_6 = 0$ as in regression (ii) we have a similar regression to the one used by Haruvy et al. (2007). Under Hypothesis 4 we should get $\beta_4 \neq 0 \wedge \beta_5 \neq 0 \wedge \beta_6 \neq 0$. In other words, there is additional

[15]Unlike Haruvy et al. (2007) the measure used here is divided by the number of participants to normalize it, which explains why the coefficient estimate is larger than the one obtained by Haruvy et al. (2007).

Table 1.12 – Regression results of (1.7), using only observations from before a crash.

	Δp_t						
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Δp_{t-1}	0.37^{***}	-0.06	0.32^{***}	-0.21	-0.27	-0.31	-0.36
	(0.08)	(0.11)	(0.08)	(0.19)	(0.18)	(0.16)	(0.21)
$p_{t-1} - f_{t-1}$	-0.10^{**}	-0.13^{***}	-0.13^{***}	-0.12^{***}	-0.14^{***}	-0.09^{**}	-0.10
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
N_t		-28.46^{***}			-21.31^{***}	-11.09	-11.62
		(5.60)			(6.20)	(5.87)	(6.90)
σ_t^m			-0.25^{**}	-0.31^{***}	-0.20^{*}	-0.45^{***}	-0.44^{***}
			(0.08)	(0.08)	(0.08)	(0.09)	(0.11)
ΔE_t				0.52^{**}	0.29	1.11^{***}	1.06^{***}
				(0.17)	(0.18)	(0.23)	(0.25)
$E_{t-1} - p_{t-1}$						-0.99^{***}	-0.88^{***}
						(0.19)	(0.23)
Session FE							✓
Market FE							✓
Round FE							✓
Num. obs.	105	105	105	105	105	105	105
R^2	0.22	0.38	0.29	0.35	0.42	0.54	0.61
Adj. R^2	0.21	0.36	0.27	0.32	0.39	0.51	0.50

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

explanatory power beyond the other variables displayed in (1.7). As can be seen from Regression (VI) and (VII), we can clearly reject that $\beta_4 = \beta_5 = \beta_6 = 0$. The only case where the coefficient on σ_t is not significant is in regression (V), but the sign and the magnitude remains in line with the other regressions, where the coefficient is significant. Table 1.11 show that our results are economically similar to results found by Haruvy et al. (2007), namely that expectations are good predictors of price movement.

1.7 Conclusion

Using an experimental asset market it is possible to shed light on the role of expectations in economic fluctuations. We investigate the role of traders confidence in creating and amplifying asset bubbles.

We embed in the workhorse of experimental asset markets, Smith et al. (1988), a novel way of eliciting beliefs. The design allows us to avoid problems of hedging and captures arbitrary distributions of beliefs.

We find that traders do indeed become more confident in their forecasts when their predictions are accurate, even if the price is above fundamental. Moreover, traders expectations tend to converge as they become more experienced.

Importantly, we find that more agreement among traders causes larger bubbles. This sheds light on the Financial Instability Hypothesis. When traders expectations are more scattered, the information is aggregated in the market in a way that dampens optimism. When expectations are more concentrated, market optimism seems to create larger bubbles, as expectations are normally around prices different than the fundamental value. Finally, market confidence has predictive power over price fluctuations, beyond the mean expectation of the market.

We see this proposal as part of a larger research agenda, particularly Aragón and Pank Roulund (2016) that extends this setup to include an endogenously generated signal. Recent neuroeconomics papers such as De Martino et al. (2013) have examined neural mechanisms explaining the occurrence of bubbles in markets where the fundamental value is known, and argue that financial bubbles are caused by error in the forecast of other participants intentions. Our proposal pretends to explore the role of this mechanism, since we intend to expand traders' information set with the distribution of beliefs of the agents.

We are also working on an experiment using the same baseline, but focusing on traders' behavior when fundamentals change in an uncertain way. This relates directly to Doblas-Madrid (2012) and in a more broad way to the recent news literature, e.g.Schmitt-Grohé and Uribe (2012). The key finding is that bubbles may be caused by an overreaction to a fundamental change. These theories are yet to be tested in economic experiments.

Chapter 2

Banks vs Zombies

2.1 Introduction

When asset prices collapse, collateral value decreases and both firms and banks become financially distressed. Insolvent agents face trade-offs that are vastly different from those faced in normal times. Not only they need to balance the costs and benefits of the investment project, but they also need to ensure their own survival. Insolvent firms continue to operate and deleverage but cease to invest in new projects, thus becoming "zombie firms." When zombies face losses, banks extend new loans to keep the firm afloat, in a process known as evergreening or zombie lending. Moreover, zombies lose access to alternative sources of funds, and face a hold up problem from their incumbent bank.

Zombie firms were first described in Japan after asset prices plunged in the early 90s. The balance sheets of financial and non-financial firms deteriorated. Banks continued to lend to zombie firms at subsidized rates to avoid recognizing their own losses. This led to widespread mis-allocation of resources, thus decreasing the overall productivity of the economy (Caballero et al., 2008). Japan's attempted to reignite growth via lower interest rates, but the efforts proved unsuccessful.

Zombie lending is not, however, exclusive to Japan. Recently, the phenomenon has been observed in China, where several state-owned enterprises are being kept afloat by the government, and also in Europe (Acharya et al., 2016). A salient characteristic of zombies is a severe debt overhang. Although decentralized debt renegotiation should lead to both parties reaching a welfare improving situation, the Japanese and European experience show that this is not necessarily the case.

The incentives of banks and firms in this scenario need to be understood in order to formulate policies to restore growth. I contribute to the literature by analyzing the incentives of lenders and borrowers to explain why zombie lending continues to thrive and is not solved by the market. I build a bank-firm game and find a set of conditions under which zombie lending arises as an equilibrium outcome. I, furthermore, provide empirical evidence using a novel panel dataset of matched firms and banks to support my findings.

The main rationale of the model is that firms that suddenly become insolvent lose access to the competitive credit market and get locked in with their incumbent bank. In other words, a hold-up problem arises. Banks can then extract more funds from the firm and may even suffocate it. Stressed firms prefer not to use funds in efficient investment, but to instead store or gamble funds away. Anticipating the firm's behavior, the financially distressed incumbent bank will not extend fresh funds. However, the bank will not liquidate the firm because such a move would increase the risk of it becoming insolvent too.

The model consists of three agents: a firm and two banks that play for three periods. The firm starts with an exogenously given level of debt contracted with one bank, the incumbent. In normal times, when initial debt is low, the firm can repay to the incumbent, and borrow from any of the two banks to finance its investment project. Banks compete *a lá* Betrand, which pushes the cost of borrowing until banks make zero profits. Firms will invest if the project is profitable.

In crisis times are modeled as a zero measure shock that hits the economy and renders firms insolvent and banks distressed. In the model, this means a high initial debt. This changes the situation dramatically. The firm is no longer able to find funds in the competitive market, and the incumbent bank becomes a monopolist. The game now becomes a renegotiation. In period one, the bank can liquidate the firm or extend credit; be it to keep it alive or to fund new investment. In period two, the firm can use the funds in three types of investment projects: an efficient yet risky investment, a storage technology or gambling. Investment increases the average level of output with a certain risk. Storage is "business as usual." In other words, the firm keeps assets asides that do not increase the average level of output. However, it still faces some profit risk. Gambling greatly increases the level of output if successful, but with a low probability. If the bank decides to liquidate the firm in the first period, it faces a shock in period two that puts it at risk of going bankrupt. In the third period the bank is either repaid or it liquidates the firm. In this model, I show that there are various situations under which the bank decides to keep the firm afloat, but not to lend for investment. In other words, the bank zombie lends.

The firm may, in order to avoid bankruptcy, use the less risky storage technology or gamble funds, even when it would be socially desirable to invest. The bank may decide not to extend enough funds to pay for the investment project for three reasons. First, it knows that any funds extended to a distressed firm without incentives to invest will end up being "gambled" with low expected returns for the bank. Second, the bank may want to extend funds to the firm just to cover for the losses and wait until it is safe to liquidate it, minimizing the chance of the firm " escaping" from the debt overhang situation. Third, the bank does not let the firm go bankrupt to avoid loosing assets and reaching the minimum capital requirements.

There is a disconnect between the incentives of banks and firms. In normal times, the bank would liquidate the firm (either by selling it or by taking an equity position) and accept a current loss. However, a weak bank may not be willing to accept such a loss, since it may increase its own bankruptcy risk.[1] Therefore, the bank chooses not to liquidate the firm.

I also discuss the special case of banks with high capital. I show that several of the results hold for capitalized banks provided that the disruption costs of liquidating firms are high enough. I then extend the model for the case of firm entry. The bank does not take into account the effect of zombie lending on maintaining a high entry cost thus deterring potential entrants. In other words, there is a pecuniary externality[2] that deters new firms from entering and decreases overall investment.

The model yields several policy prescriptions. Firstly, a haircut on firm debt increases welfare. A firm in debt overhang faces higher liquidation risk. A haircut lowers that risk thus inducing firms to invest. Social surplus is maximized. A mild bank recapitalization without a haircut on corporate debt does not change the firm's incentives and is not enough to resume investment. A large recapitalization will induce efficient liquidation of firms, but not investment. The optimal policy response to zombie firms should include both bank recapitalizations and debt haircuts.

Secondly, monetary policy is ineffective in the presence of zombie firms. In other words, a decrease in the interest rate may not induce higher investment or efficient liquidation. A lower interest rate reduces the opportunity cost of funds to lend, whether it is for keeping firms afloat or for investment. In the model with entry, a decrease in the interest rate is not only ineffective but also counterproductive, as it decreases the incentives to liquidate quickly.

Finally, relaxing capital requirements may induce the efficient liquidation of insolvent firms. When undercapitalized banks refuse to liquidate, a temporary decrease in the capital requirements will allow them to liquidate firms without approaching the constraint and risking its bankruptcy.

To support the theoretical implications of the model, I create a panel dataset by matching Spanish firms and banks for the 2006-2013 period. Zombie firms are those that are unable to service the interest payments on debt and that simulatenously receive below the market rates, i.e subsidized lending. Weak banks are those with low capital with respect to the minimum capital requirement.

I provide evidence of the following facts that support the model: (1) weak firms are disproportionately coupled with weak banks; (2) undercapitalized

[1]It is well documented that undercapitalized banks are more likely to go bankrupt (Corbae and D'Erasmo, 2014a).

[2]As in Greenwald and Stiglitz (1986).

banks tend to lend relatively more to their more indebted borrowers, (3) more indebted borrowers invest relatively less when coupled with an undercapitalized bank; and (4) undercapitalized banks are less likely to liquidate their more indebted borrowers. Facts 2 and 3 were also found for the case of Japan, while facts 1 and 4 are new and contribute to the empirical literature on zombie firms.

The paper is structured as follows. Section 2.2 fits this paper in the literature. Section 2.3 presents soft evidence for Japan and empirical evidence for Spain. Section 2.4 presents the model. Section 2.5 discusses the results and concludes.

2.2 Related Literature

The theoretical contribution of the paper bridges two branches of the literature: debt renegotiation and forbearance, and debt overhang. The empirical section of the paper contributes to a new literature on firm-bank linkages. Finally, the model has policy implications of relevance for a stagnant economy at the zero lower bound.

In a classic paper, Myers (1977) shows that debt overhang leads to under-investment by firms. This is because it is harder to raise capital for new investments, given that the profits would benefit existing debt holders first instead of the new investors. Moreover, it has long been argued that firms in financial distress have an incentive to gamble with their assets due to limited liability, (Adler, 1995). Following Myers (1977)'s assumption of debt seniority, I nest both insights. I further analyze the effect on investment of the monopolistic power created by the senior lender and analyze why renegotiation does not solve the problem.

The literature on debt forbearance focuses on the “soft budget constraint” of indebted firms that the government keeps alive to avoid the social cost of firm liquidation (Berglof and Roland, 1998). I go further and show how banks, as profit seeking agents, can end up in the same situation.

The setup of the model relates to the literature on corporate debt as in Thomas and Worrall (1994) and Albuquerque and Hopenhayn (2004). In these papers there is a single lender and the agents sign a multiperiod contract. My model instead focuses on many lenders and period by period negotiations with overly indebted borrowers. Another point where my paper departs from the literature is that instead of passive lenders I take into account the incentives of both creditors and firms. The incentives of the lender have only been analyzed by Kovrijnykh and Szentes (2007) in the context of sovereign debt, which is thoroughly discussed in Section 2.4.4.

The zero lower bound has long been used to examine the behavior of stressed economies; e.g Krugman et al. (1998). In such papers, monetary expansion is believed to be temporary, and thus monetary policy is ineffective. Krugman et al. (1998) also claims that Japanese banks are not the central problem of the crisis. The policy implications of my model are in stark contrast to this view. Monetary policy is ineffective because it makes it cheaper for banks to provide zombie lending instead of funding investment, and the financial stress of the banks is key for the mechanism.

My paper also contributes to two strands of the empirical literature: the literature on zombie firms and the recent literature on firm-bank lending behavior.

The first paper to identify zombie firms empirically is Caballero et al. (2008) for the ca se of Japan, and also shows the negative effect on productivity and firm entry. Many papers follow this line of research, among them Imai (2015), Fukuda and Nakamura (2011), Ogawa (2003) and Ahearne and Shinada (2005). These papers focus on firms, disregarding the role of banks. I show commonalities for the case of Spain and further analyze empirically the probability of liquidation by exploiting a dataset on firm ownership before and after the crisis.

There is a body of literature that analyzes firm-banks linkages empirically. Peek and Rosengren (2005) analyze zombie lending in Japan with a dataset of matched firms and banks and find that weak banks tend to lend to poorly performing firms. Acharya et al. (2016) analyze the real effects of the Outright Monetary Transactions Program, which increased the price of sovereign debt, thus recapitalizaing banks. Using a dataset with transaction level data for Italian banks, they find that banks that were recapitalized did increase their lending to zombie firms, and that these firms built up cash reserves instead of investing. Thus, the effect on real economic activity was null. The results are consistent with this paper, but I further link the results to firms' characteristics.

Bentolila et al. (2013) analyze whether the solvency of Spain's weakest banks had real effects. They find a credit supply shock differentiating the case of weak and solvent banks between 2006 and 2010. My empirical analysis is consistent with these facts for the case of Spain. Moreover, I unveil a new fact by exploiting ownership data; namely, that weak banks tend to liquidate weak firms relatively less.

2.3 Empirics

In the first subsection I show a number of stylized facts from the Japanese Experience. In the second subsection I present empirical evidence for the case of Spain in which I highlight commonalities between the two episodes.

2.3.1 The Japanese Experience

Zombie firms were first identified in Japan after the burst of asset and real state prices in 1991. There are a number of stylized facts that both motivate and guide this paper.

Japan has experienced a stagnation since then. The literature identifies two reasons explaining this slowdown. A strand of the literature argues that there was a credit crunch, given that banks had to comply with the international standards governing minimum capital requirements. The fear of falling below the minimum capital requirement led many banks to rollover debt to insolvent borrowers, gambling that these firms would recover or that the government would bail them out. The Japanese government encouraged banks to increase lending but it was unsuccessful. On the other hand, Koo (2011), coined the term *Balance Sheet Recession*. Koo's theory is that companies respond to a financially distressed balance sheet by minimizing debt instead of maximizing profits. Monetary policy, in this situation, is ineffective because indebted firms do not want to borrow, no matter how low the interest rate is. My theory bridges these visions organically and shows how this happens in a profit maximizing framework.

Caballero et al. (2008) identify zombie firms as those receiving a subsidized rate in their loans. They found zombies to be prevalent, as can be seen in Figure 2.1. The first notable fact is that the phenomenon spiked with the collapse of a bubble, when asset prices began to fall in Japan in 1991. The behavior of the Tokyo Price Index (TOPIX) can be seen in the right panel of Figure 2.1.

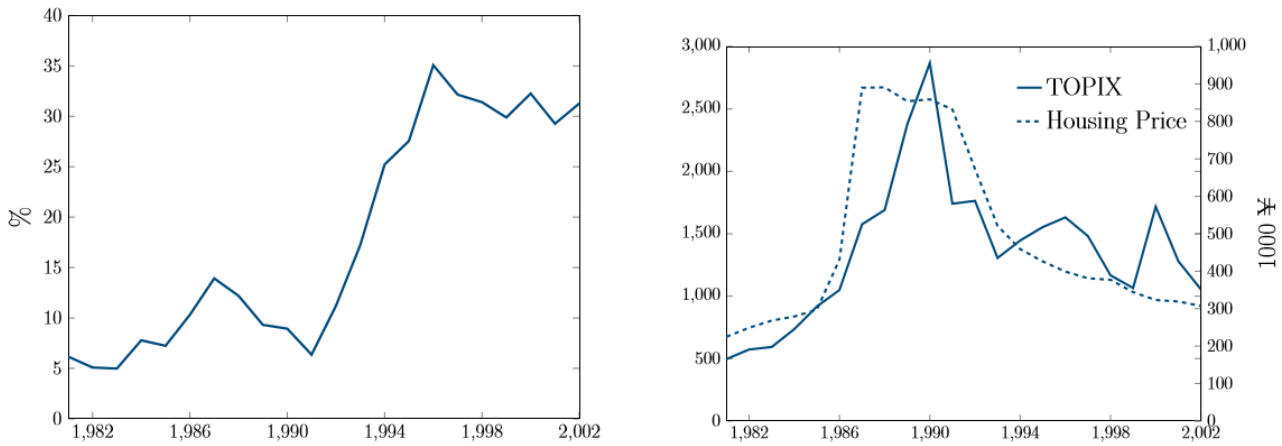


Figure 2.1 – Left: Zombie Index in Japan (raw percentage of firms). Right: Asset prices in Japan. Source: Caballero et al. (2008) and Koo (2011)

Caballero et al. (2008), Ahearne and Shinada (2005) and Ogawa (2003) show that the presence of zombie firms had negative effects on job creation and productivity in zombie dominated industries. Moreover, zombie lending distorted the competition for the rest of the economy and negatively affected healthy firms and firm entry.

A relevant feature of the Japanese case is that firms started to deleverage but failed to invest. In other words, firms attempted to improve their balance sheets (Koo, 2011). This can be observed in Figure 2.2.

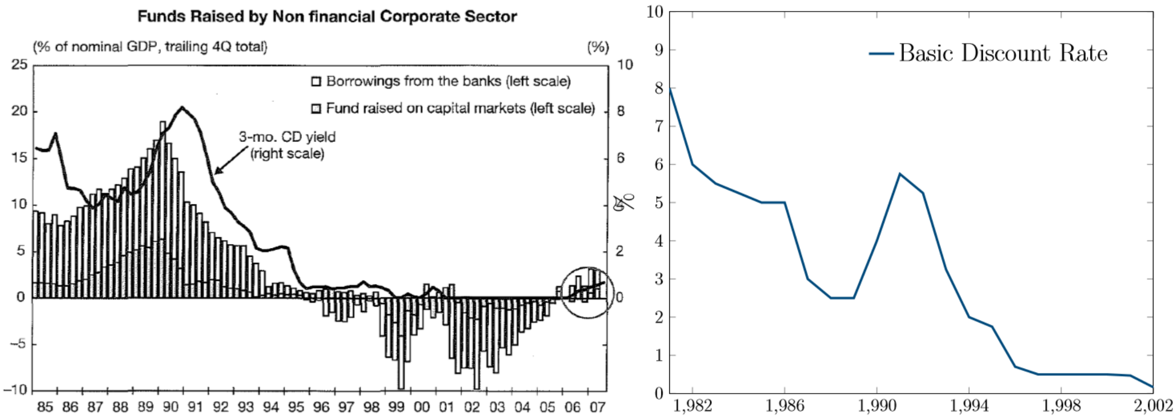


Figure 2.2 – Borrowing by the Non Financial Corporate Sector and interest rates. Source: Koo (2011) and Bank of Japan.

A final salient feature of the Japanese stagnation is that, despite lower interest rates for decade, investment did not reignite. Several authors[3] claim that the problem was the zero lower bound, since the equilibrium real interest rate was below zero. I offer a different explanation on why the interest rate did not work, based on the fact that it makes it cheaper for the banks to provide survival lending.

2.3.2 Empirical Evidence

I now document some facts for Spain. First, I identify zombies using a refined version of the method in Caballero et al. (2008) . I then show that weak firms are normally in a lending relationship with a weak bank. I then show the following facts: (i) weak banks tend to lend more to less healthy borrowers, (ii) Less healthy borrowers invest less if they are paired with a weak bank, (iii) weak banks tend to liquidate firms less often. I propose a model in the next section to account for the observed pattern in the data.

Data Description

I create a novel dataset to analyze bank-firm lending patterns in Spain. I do so by matching data from two sources: Amadeus and Bankscope, that provide data on firms and banks respectively. Both databases are compiled by Bureau van Dijk Electronic Publishing,. Linking the two datasets allows me to analyze how bank lending behavior can affect real variables.

The data is annual and follows Spanish firms in the 2006-2013 period. The choice of Spain is due to the economic conditions relevant for the phenomenon of zombie lending were present. Similarly to Japan a real state and asset price

[3] For example, Krugman et al. (1998).

bubble burst, distressing bank capital and firm debt. The selection of the period from 2006 until 2013 was chosen to be 3 years before and 3 years after the crisis.

Amadeus provides financial and non financial firm level data that covers over a hundred countries, since as early as 1996. It contains balance sheet information from financial and non financial firms. Importantly, less than 2 percent of the firms are publicly listed, so it is mainly composed of small and medium size companies, which account for over 80 percent of the GDP. In Europe, reporting is a regulatory requirement, thus firm coverage is superior. Amadeus also provides a four digit NACE classification for sectors and description of ownership. Coverage for the particular case of Spain is about 88 % of firms (Kalemli-Ozcan et al., 2015). The panel is strongly balanced, since there are not many missing values.

Bankscope is a database of 32,000 public and private banking institutions worldwide. The database provides comparable financial statements of banks of different size. Reports contain consolidated balance sheet and income statements. It contains all of the 389 banks operating in Spain during the period as well as the international banks that Spanish firms were using.

I compile the dataset matching banks and firms in Spain. Amadeus provides the name of the main bank of the firm, a limitation of the data that requires the assumption that a firm gets all its bank loans from that bank. I match these names to Bankscope. As Kalemli-Ozcan et al. (2015) show, firm bank relationships do not change significantly across time.

A main challenge when matching the two databases is that the Bank's name in Bankscope is not identical to the Bank's name in Amadeus. Specifically, Bankscope has data on all the different subsidiaries of a given Bank as well as the data on the ultimate owner of the Bank, whereas Amadeus only provides the banker's name in a more general format. For this reason I decided to use for the Bank, the data from Bankscope's global ultimate owner. Put differently, firms which main bank were subsidiaries of a given owner were taken as having a lending relationship with the ultimate owner. It can be argued that a more disaggregated match would be desirable. This was not done for three reasons. Firstly, the data on subsidiaries tends to be more incomplete. Secondly, the match is easier since sometimes the names of the subsidiaries are very similar and Amadeus data is not enough to make a distinction. Finally, rescues within branches of the same bank are common and therefore the capitalization in the books of a subsidiary is no necessarily relevant.

Over 93 percent of the firms in the original database was matched to its main bank. Out of the 389 banks in Bankscope, I matched 221 of them to 136 ultimate owner banks. Unmatched banks, mostly small rural banks (*Cajas*), normally were not the main bank of the firms. Unmatched firms were either medium or small size, but not systematically one or the other.

There were substantial mergers and acquisitions of banks during the time pe-

Table 2.1 – Descriptive Statistics of Matched Data

Firms				
	Obs	Mean	Min	Max
Net Investment/Capital	122,886	0.14	-0.79	4.20
Short Term Debt/Assets	145,753	0.48	0.00	1.32
Long Term Debt/Assets	127,425	0.18	0.00	1.05
Debt/Assets	127,343	0.68	0.03	1.83
Sales Growth	96,560	0.03	-1.70	1.72
log(Assets)	146,114	15.2	9.90	19.21
Net Worth/Assets	127,343	0.38	-1.70	0.96
Long Term Debt/Debt	127,343	0.41	0.00	1.00
Ebitda/Debt	127,213	0.22	-0.42	1.68
Banks				
	Obs	Mean	Min	Max
Leverage	140,845	15.4	0.091	87
Assets	151,836	1.16	0.001	19.1
Capital	140,845	0.09	0.007	0.344
Risk Adj Capital	139,700	0.07	0.008	0.262
Tier 1 Capital Ratio	139,709	9.67	0	64.42

Bank Assets and Capital are in billions of Euros.

riod. I kept track of this using Mariathasan and Merrouche (2012) and Spain's Central Bank official bulletin.

I drop firms in the government and financial sectors for the study. This is due to the fact that the model is focused on real activities and that government companies are normally heavily regulated, in terms of pricing and investment decisions. I also deflate financial variables using the GDP deflator.

In Table 2.1 the descriptive statistics of matched firms and banks are provided. The statistics of unmatched data are provided in Appendix B.1.1.

Identifying Zombies

I first identify zombies in Spain expanding upon Caballero et al. (2008)'s method. In their criterion, zombie firms are those that receive subsidized lending. They create a theoretical lower bound on the cost of lending, $R^\star$ and compare that to the actual interest payments made by firm i in period t, $R_{i,t}$. If the firm is receiving its lending at a subsidized rate, they consider the firm a zombie. However, there are many reasons why firms are receiving credit at below the market rates that are not necessarily zombie related. To filter these other reasons, I add a solvency criterion similar to Acharya et al. (2016). In other words, I consider a firm a zombie if profits were insufficient to pay for the services of debt and the firm in addition receives subsidized credit.

Put differently, in addition to Caballero et al. (2008)'s criterion, I compare whether potential interest payments on previous debt $R^{\star}_{t-1}B_{t-1}$ were feasible given realized profits. The construction of this variable is carefully explained in Appendix B.2.

Using these criteria I identify zombies in the sample. These are plotted in Figure 2.3. In the left hand side I plot the fraction of zombies and the proportion of those zombies that were in a lending relationship with a weak bank. A bank is defined as weak using several definitions and results are robust across them. In the reported tables I define banks as weak when they are 1 percentage point above the minimum capital requirement, which is normally not binding.[4]

Figure 2.3 shows that, similarly to what Caballero et al. (2008) found for Japan, the spike in zombie firms is simultaneous with the collapse of the real state bubble in Spain. Moreover, zombie firms are disproportionately coupled with weak banks.

Importantly, for an individual firm, the state of being a zombie is highly persistent: a firm that is considered a zombie in a given year, has a 0.87 chance of remaining as such in the following year.

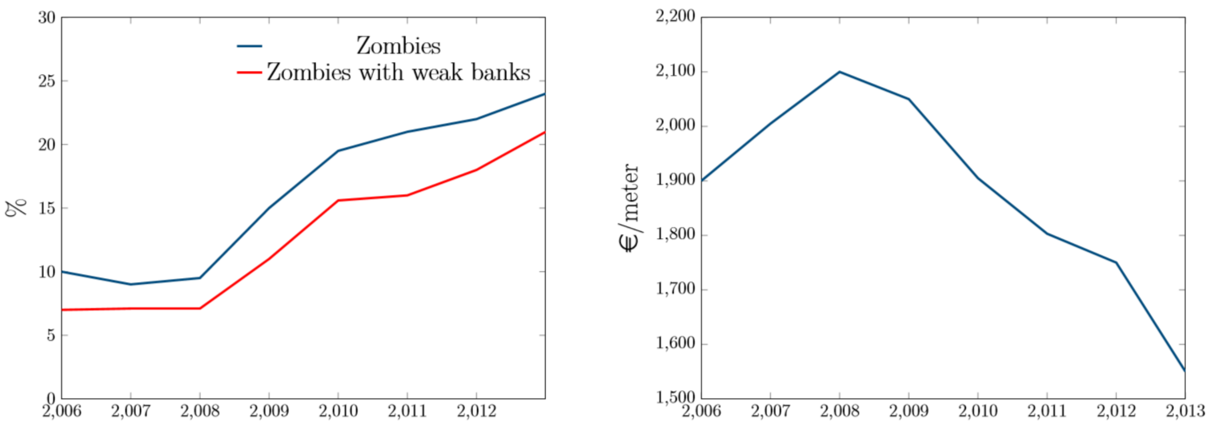


Figure 2.3 – Left: Zombie Index in Spain (raw percentage) and land prices.

Weak Banks Lend to Weak firms

The hypothesis of this subsection is that a weak bank will be more likely to extend new loans to troubled firms. The rationale behind this hypothesis is that by doing so, the bank avoids recognizing the losses and the risk of hitting the minimum capital requirements if the firm goes under. This allows the firm to avoid bankruptcy and the bank to smooth losses across time.

[4] Other measures used are CDS spreads -only available for large banks-, "distance to default" (see Kliestik et al. (2015)), ECB's stress tests (available only for a limited number selected years, but was highly criticized for understating bank risk), the ratio of impaired Loans in $t+1$ to assets and the ratio of assets to capital.

The basic regression to test for this hypothesis is

$$Loan_{i,j,t} = \alpha_0 + \alpha_1 Overhang_{i,j,t-1} + \alpha_2 WeakBank_{i,j,t-1} + \alpha_3 Interaction + \alpha_4 X_{i,j,t} + \epsilon_{i,t,t},$$

where $Loan_{i,j,t}$ is a dummy variable equal to one if the firm i received additional loans from its main bank j in period t and zero otherwise.

Firm Health is measured in several ways. Among the variables for firm health are the return on assets, return on equity and as (the additive inverse of) several measures of debt overhang. The measures of corporate debt overhang in the literature are several. The most common is the amount of long term debt to total debt, in the spirit of Myers (1977). Some authors claim that short term debt may cause overhang as well through increased rollover risk (Diamond and Rajan, 2009). Therefore I also use share of total debt to total assets. Most of the results are, however, robust to changes in the variables used. The results reported throghout this section are those with Firm Health proxied as the share of long term debt over total debt, corresponding to the classic definition of debt overhang.

The key variable to test the hypothesis is $Interaction$, which is defined as the multiplication of the dummy $WeakBank$ and $Overhang$. $X_{i,j,t}$ is a vector of control variables that include sales growth, the logarithm of total assets, liquid assets and firm size. I also include fixed effects to account for unobserved heterogeneity. Baseline specification uses sector-year fixed effects to account for changes in demand at the sector level (2-digit NACE classification). The equation is estimated via least squares with robust standard errors and fixed effects.[5]

Table 2.2 shows that healthier firms (lower debt) during the previous year do indeed receive more loans, and that a weak bank lends less, everything else constant. The important effect for this paper is the interaction which is negative and significant. This implies that a weak bank tends to lend less to healthy firms.

I run two additional non-panel regressions. The first one is for year 2008 in which the interest rate was 4 percent, and the other for the year 2013 when the interest rate was less than one percent. The coefficient on the interaction becomes insignificant for 2008 and significant and higher in absolute value for 2013. This is in accordance to the prediction that forbearence is more important in periods of low interest rates.

Firms Coupled with a Weak Bank Invest Less

This hypothesis is similar to a standard debt overhang hypothesis (i.e, more indebted firms invest less) but I also explore whether there is an amplification

[5] It was also estimated using the panel logit model but this presents the incidental parameter problem. In any case, marginal effects in both models are very similar.

	Full Sample		2008		2013	
	(1)	(2)	(1)	(2)	(1)	(2)
Overhang	-0.03^{***}	-0.031^{***}	-0.04^{***}	-0.01***	-0.03***	-0.014^{***}
	(0.001)	(0.007)	(0.102)	(0.003)	(0.001)	(0.004)
Weak Bank	-.0096***	-.0047***	-.0012***	-0.008***	-0.0051***	-.0142***
	(0.003)	(0.001)	(0.001)	(0.002)	(0.001)	(0.004)
WBank× Overhang	0.0011**	0.002**	0.0007	0.006	0.008***	0.004***
	(0.06)	(0.001)	(0.004)	(0.004)	(0.002)	(0.001)
year FE	✓	✓	✓	✓	✓	✓
Sector FE		✓		✓		✓
Observations	89,938	89,897	8,746	8,746	11,058	11,058
R^2	.24	.26	0.12	0.12	0.12	0.14

Clustered SE at firm level in parentheses. *** $p < 0.01$, ** $p < 0.05$,* $p < 0.1$

Table 2.2 – Lending. Dependent variable: Loan increase (Dummy)

	Investment	
Marginal Q	0.006***	0.005***
	(0.002)	(0.002)
Overhang	-0.093***	-0.081***
	(0.028)	(0.03)
Weak Bank×Overhang	-0.012***	-0.02***
	(0.004)	(0.006)
Firm Controls	✓	✓
Sector FE	✓	✓
year FE		✓
Observations	89,938	89,897
R^2	0.08	0.09

Clustered SE at firm level in parentheses.
*** $p < 0.01$, ** $p < 0.05$,* $p < 0.1$

Table 2.3 – Investment

when the firm is coupled with a weak bank.

The main regression is

$$\frac{I_t}{K_{t-1,i}} = \beta_0 + \beta_1 Mq_{i,j,t} + \beta_2 Overhang_{i,j,t-1} + \beta_3 WeakBank_{i,j,t-1} + \beta_4 Interaction + \beta_5 X_{i,j,t}$$

This is very similar to the previous section. The main difference is the outcome variable and the inclusion of variable Mq, which is Tobin's Marginal Q. This was constructed following Chung and Pruitt (1994) and is further described in Appendix B.2.

Table 2.3 shows that firms with a high Q invest more. Less healthy (more indebted) firms invest less. Both of these facts are consistent with the literature on debt overhang . The coefficient relevant for this paper is the interaction. A weak firm's ability to invest is lower when its main bank is weak. This fact along with the increased likelihood of receiving a loan from a weak bank when the firm is weak hints to the existence of survival lending.

Weak Banks tend to liquidate firms less often

A third hypothesis is that weak banks, acting in their own self interest, would be less likely to liquidate or absorb insolvent firms. The rationale is that, in this way, banks avoid showing losses in their books and risking their own bankruptcy or the prestige of the executives.

Amadeus provides data on ownership structure of firms, including name of the owners and percentage stake on the firm. Unfortunately, there is no time series data. To circumvent this limitation I use data form the 2006 Amadeus CD. Therefore, I observe ownership structure in 2006 and 2015. Using this I construct an admittedly imperfect measure of liquidation of firms by banks.

The description of the construction of this index is detailed in Appendix B.2. I consider three measures of liquidation or absorption. A firm is considered liquidated when the ownership structure of over 50 percent of its shares changed owners or when the bank takes a significant share of ownership.

The regression is as follows,

$$Liq_{i,j,2015} = \gamma_0 + \gamma_1 Overhang_{i,j} + \gamma_2 WeakBank_{i,j} + \gamma_3 Interaction + \gamma_4 X_{i,j,t} + u_i$$

The variabel $Liq_{i,j,2015}$ is a dummy variable that takes the value 1 if the firm i with a lending relationship to bank j was "liquidated" between 2006 and 2015, in the previously defined way. The variable $FirmHealth$ and $WeakBank$ are defined as averages over 2009-2013; the period after the burst of the bubble.

The results are reported in Table 2.4. Firms with a more serious problem of debt overhang (less healthy) are more likely to be liquidated. Weak Banks are more likely to liquidate in general. This is reasonable since these banks are probably weak because they were disproportionately affected by the fall in asset prices through their borrowers. The Interaction coefficient shows that firms with a higher debt overhang coupled with a weak bank are less likely to be liquidated or absorbed.

	(1)	(2)
Overhang	0.029***	0.023***
	(0.001)	(0.008)
Weak Bank	0.012***	0.013***
	(0.005)	(0.004)
Weak Bank×Overhang	-0.090**	-0.074**
	(0.048)	(0.034)
Observations	22,028	22,028
R^2	0.01	0.03

Specification (1) uses Liquidation index 1.
Specification (2) uses Liquidation index 2
For more, see description in Appendix B.2
Clustered SE at firm level in parentheses.
*** $p < 0.01$, ** $p < 0.05$,* $p < 0.1$

Table 2.4 – Liquidation

2.4 The Model

I now describe a simple game that provides theoretical insights on the behavior of borrowers and lenders in a situation of debt overhang and near bankruptcy.

I show that the incentives of banks and firms differ in a near bankruptcy situation and the decentralized equilibrium may be Pareto inefficient. Particularly, I show how firms can fail to invest even when there are profitable opportunities and banks have funds to fund new them. Furthermore, I analyze different policies and show how they can improve this equilibrium.

2.4.1 Setting

There are three risk neutral agents in this economy: a firm and two banks. They live for three periods. In normal times, the two banks compete *a lá* Bertrand to provide funds for investment. The risk-free interest rate is $R > 1$.

The firm posseses a technology that allows it to have a random profit. Average profit is y in each remaining period without further investment.

The firm has access to a risky investment technology that would induce an increase in average profits from y to $\bar{y} > y$, with a variance σ_ϵ. The cost of investment is X . The firm can also use the X funds to gamble. Gambling is a priori an inefficient technology that increases output to $\tilde{y} >> \bar{y}$ with probability γ, which is small. If the firm is unable to or decides not to invest or gamble, it can store S units of funds and keep them until the next period. Since y is random, the firms' profits will still be hit by a profit shock with variance σ_ν.

I make the following assumption regarding probabilities

Assumption 1. *The investment project is distributed according to $G \sim \mathcal{N}(\bar{y}, \sigma_\epsilon)$, the storage follows $H \sim \mathcal{N}(y, \sigma_\nu)$, and the gambling project returns $\tilde{y}$ with probability γ if successful or 0 otherwise. The distributions satisfy the following*

- $\sigma_\epsilon > \sigma_\nu$
- $\gamma\tilde{y} < y < \bar{y} < \tilde{y}$

The assumptions imply that investing in the risky technology has a higher variance and and a higher mean return than storage. Gambling has an expected value that is lower than storage but, if successful, it provides a larger payoff than the efficient investment. Efficient investment will increase the productive capacity of the firm discretely manner, as is the case of research and development.

These assumptions make, effectively, the distribution of profits as in Figure 2.4. The height of the red bar is γ, the probability of success when gambling.

I abstract from limited commitment from both the bank and the firms, as well as moral hazard in risk taking ex ante. One key issue is that investment is non contractible and therefore the contract must take into account incentive compatibility. Moreover, the bank's offer is non state contingent.

2.4.2 Normal Times: Competitive Lenders

If the firm has access to competitive lending, competition will push towards zero profits for banks. Therefore,

$$RX = \alpha(b)b + (1 - \alpha(b))\ell$$

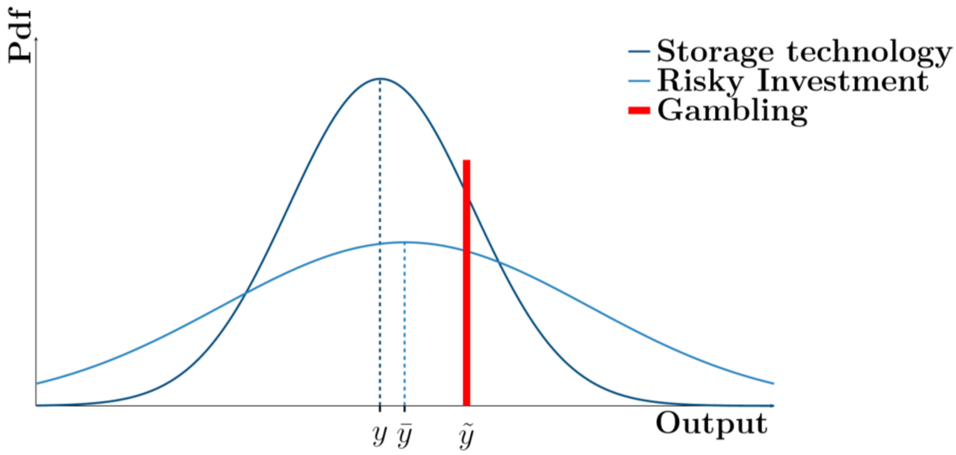


Figure 2.4 – Assumption 1

Banks equate the opportunity cost of extending X funds to the firm, RX to the expected repayment from the firm. $\alpha(b) = Prob(\epsilon > b - \bar{y})$ is the probability of survival if the firm invests, and the debt to be repayed is b. In other words, if successful, the firm will pay b, and if not, the bank will be able to liquidate the firm and obtain ℓ. This leads to

$$b^C = \frac{1}{\alpha(b^C)}(RX - (1 - \alpha(b^C))\ell)$$

For the purposes of analyzing investment, I use the following definition

Definition 1. *Investment is efficient if*

$$\alpha(b^C)\left(\bar{y} - y + E(\epsilon|survival - E(\nu|survival)\right) + (1 - \alpha(b^C))V^\ell > X$$

Investment is efficient only if the expected profits are greater than the cost of investment and the expected costs of disruption, at the competitive rate.

The following proposition characterizes the investment in normal times.

Proposition 1. *If investment is efficient and disruptions costs are "low", then investment dominates storage and gambling at the competitive rate.*

This proposition says that when there is no debt overhang, the bank will fund investment at the competitive rate, b^C, and that the firm will decide to invest, given its incentive compatibility constraint.

2.4.3 Crisis Times: Monopolistic Lender and Restructuring Game

In period zero, the firm has an inherited level of debt, b_0, with one bank - the incumbent. In "Crisis Times" , the inherited level of debt is hit by a zero measure shock in $t = 0$, such that the firm becomes insolvent (i.e, debt is higher than the net present value of the firm). I make the following assumption following Myers (1977) and Kovrijnykh and Szentes (2007),

Assumption 2. *Old debt is senior to new debt*

This assumption is of central importance for the results of this paper. When debt is shocked towards unsustainable levels, the second bank would never lend given that any profit would be first received by the incumbent bank. Therefore, the incumbent bank becomes a monopolist.

Since the firm cannot pay, the bank decides whether to restructure this debt or liquidate the firm. If the bank extends new loans, the firm can decide whether to invest, store or "gamble" the funds.

In period 1, the bank observes the firm's realized profits, y_1, and debt level, b_0. The bank then decides whether to renegotiate or liquidate the firm. The bank also has access to the risk free interest rate that yields R at the end of the game. If the bank renegotiates in the first period, it will make a take-it-or-leave-it offer consisting of an immediate payment and a future payment, (r, b). The first component is payed in the first period and the second component is payed at the end of the second period. These offers are constrained by the outside option of the firm, such that firm's profits, π, should be greater than the outside value, V^ℓ.

In the case that the bank decides to liquidate the firm in period 1, it gets the liquidation value, ℓ and the firm gets a payoff of $V^\ell < 0$. However, there is a shock to bank capital that will be realized in $t = 2$. Banks have minimum capital requirements, K and assets $g(b_0)$ in their books, where $g(\cdot)$ is an increasing function. When bank capital falls, the risk of bankruptcy increases. Therefore, when banks renegotiate debt, they increase the likelihood of their own demise.

The timing of the restructuring game is depicted in Figure 2.5, and is as follows

- In period 0 firms have an inherited debt level and are insolvent. The bank can renegotiate the debt or liquidate the firm.
- In period one,
  - If the bank made an offer (r, b) and it is accepted, the firm decides whether to invest in a risky technology, gamble, or store.
  - If the bank liquidates the firm, the bank faces a shock to its profits that increases its risk of bankruptcy.
- In period two, all uncertainty is resolved;
  - If the firm received new credit, the shock to firm's profits is realized.
    * Profits will be $\bar{y} + \epsilon$ if the firm invests, with $\epsilon \sim G(0, \sigma_\epsilon)$
    * Profits will be $y + S + \nu$ if the firm stores, with $\nu \sim H(0, \sigma_\nu)$.

    * Profits will be $\tilde{y}$ if the firm gambles and succeeds (with probability γ) or zero if it does not succeed (with probability $1-\gamma$).
  - If the bank liquidated the firm, the shock to its capital is realized
- At the end, debt is either repayed or the firm is liquidated.

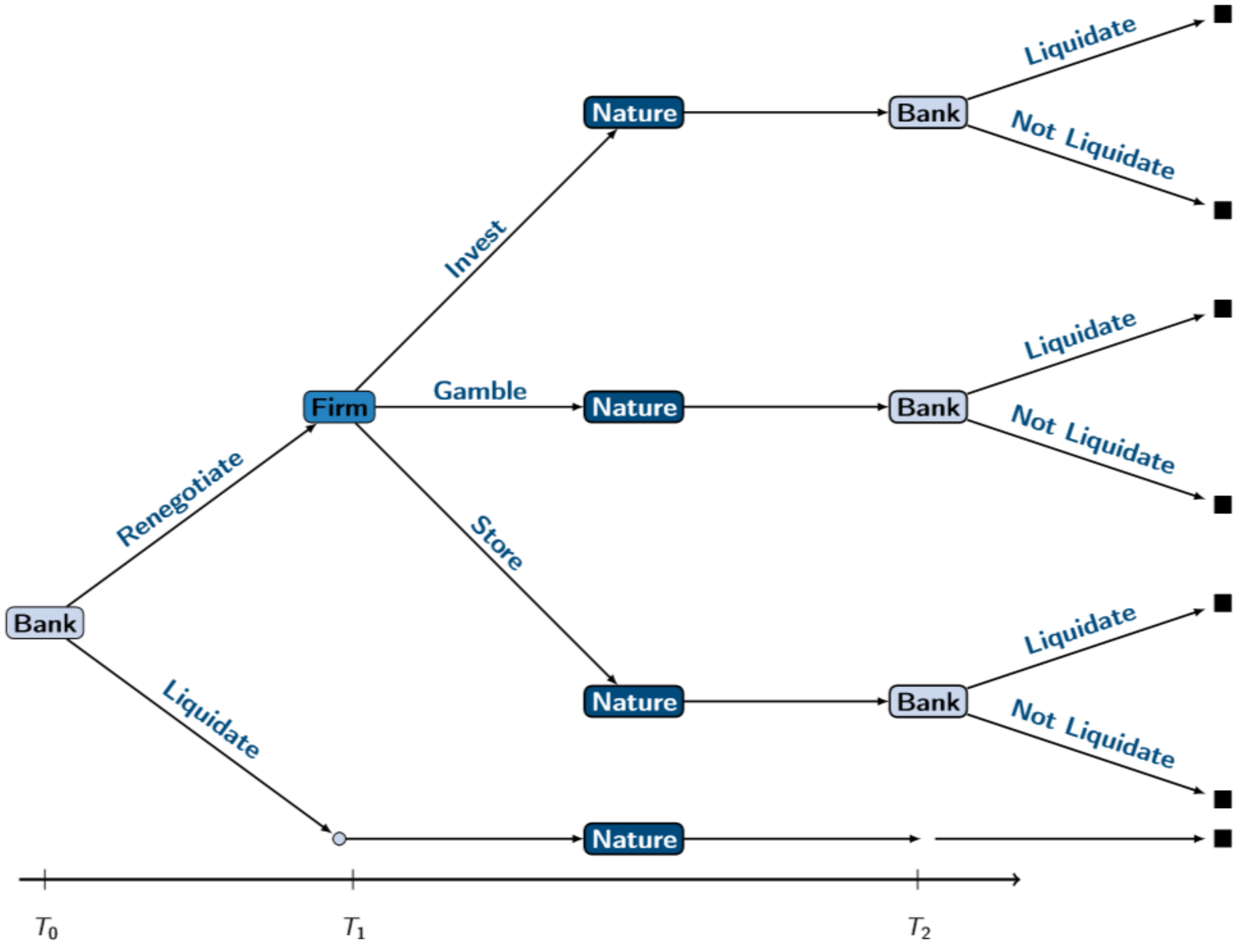


Figure 2.5 – Timing of the Renegotiation Game

Firm's Problem

Firms net profits in the first period are given by

$$\pi = y_1 - r - X(I) - S$$

The profit shock in period 1 is y_1, which is obtained from a normal distribution with mean y. If the bank restructured the debt of the firm, it must pay r. Note that both r and y_1 can be either positive. In other words, the firm can be making a current loss (in which case it needs $r < 0$ to be kept afloat) or positive (in which case the firm can pay some amount back to the bank, $r > 0$).

$X(I)$ is the cost of investing or gambling,[6] and can be either $X > 0$ if the firm decides to use the funds or 0 if the firm does not invest. S is the amount of storage that the firm chooses. For simplicity in notation, I assume that the firm either invests or stores and does not do both.[7]

In the second period, firm's profits will depend on the activity that it pursued in the first period. If the firm invests, expected profits at the end of the game are

$$\alpha(b)(\bar{y} - b + E(\epsilon|survival)) + (1 - \alpha(b))V^{\ell}$$

where $\alpha(b) = Prob(\epsilon > b - \bar{y})$ is the probability of survival if the firm invests and the debt to be repayed is b. In other words if the firm succeeds, it can repay the principal b and enjoy the profits. If the firm cannot pay up it will be liquidated and get a negative payoff of V^{ℓ}.

If, on the other hand, the firm decided to store in period 1, then the firm's expected profits in $t = 2$ will be

$$h(b)(y + S - b + E(\nu|survival)) + (1 - h(b))V^{l}$$

where $h(b) = Prob(\nu > b - y - S)$ is the probability of survival is the firm stores the funds. The firm will get the remaining profits after paying the debt in the second period if it can indeed repay the debt or will get the negative payoff of being liquidated if the funds are not enough. Note that the mean profit, y, remains the same.

The reason for the randomness in the storage technology deserves some discussion. The technical reason is that if there is no randomness, the firm will know with certainty if by storing it will be able to cover its debt or not and makes the problem non differentiable and therefore less tractable. An intuition for this explanation is that storage is perfectly safe but the firm faces a normally distributed profit shock with mean zero. Given the normality assumption, these can collapsed into one normal distribution with mean y and variance ν.

In case the firm decides to use the funds to gamble instead of investing or storing, profits will be

$$\gamma(\tilde{y} - b) + (1 - \gamma)V^{\ell}$$

In other words, with probability γ, the firm obtains a very large $\tilde{y}$, but with probability $1 - \gamma$ the gambling is unsuccessful and the firm goes bankrupt.

Bank's Problem

The behavior of the bank depends on firm's debt. If debt is low, then both banks compete pushing the cost of debt to the opportunity cost of funds,

[6] This is without loss of generality and for simplification purposes.

[7] A fact that is true in equilibrium due to indivisibility of investment.

adjusted by the default probability. This is the competitive case. Since banks are risk neutral, they make zero profits. However, if debt suddently becomes large, then by the seniority assumption, the bank becomes a monopolist, and can decide whether liquidate the firm or restructure debt.

In case the bank liquidates the firm at the beginning of the game, it gets the liquidation value, ℓ. This will report $R\ell$ at the end of the second period, since it puts it in the risk-less technology. However, if the bank liquidates, it also writes down the value of the assets and gets closer to its minimum capital requirements, K. Bank capital is subject to a shock between period 1 and 2, that pushes it closer to the capital requirements and thus increases the risk of bank bankruptcy. I assume that the bank will be capitalized at the end of the game if it decides to renegotiate the debt with the firm.[8] Therefore, the bank has a probability of bankruptcy of $\psi + f(b_0) < K$, where ψ is the shock, K is the minimum capital requirement and $f(\cdot)$ is an increasing function of the assets in the book. If the bank goes bankrupt it gets a payoff of $V^B < 0$.

If the bank decides to restructure debt, it will get an immediate payment of r, which will lead to an end of the game payoff of Rr. It is important to emphasize that r may be either negative (in which case it extends a credit to the firm) or positive (in which the firm pays part of its debt). If r is negative, Rr represents the opportunity cost of the extra funds that the bank lends to the firm.

In case the bank restructures the debt, it will get, in addition to rR, a final payoff of either b or ℓ, depending on whether the firm is able to repay the debt or not. It is worth noting that the original debt, b_0 is a sunk cost for the bank and thus has no effect on the final payoffs.

The bank problem is then,

$$\begin{aligned} \max_{\{(r,b),liquidate\}} E\pi^B &= \max_{\{(r,b),liquidate\}} \left\{E\pi^B_{inv}, E\pi^B_{st}, E\ell R\right\} \\ &\text{subject to} \\ &\max_{I,S,G} \left\{E\pi^I, E\pi^S, E\pi^G\right\} \end{aligned} \tag{2.1}$$

The bank has strategies $(\ell, (r, b))$ and the firm has strategies $(Invest, Save, Gamble)$. The bank maximizes its expected profits $E\pi^B$ by choosing a combination of immediate payments and future payments, r and b, subject to the reaction function of the firm. The firm will choose whether to Invest, Gamble or Store, I, S, G to maximize its expected profits from investing, storing or gambling, $E\pi^I, E\pi^S, E\pi^G$.

[8]There are two reasons for this assumption. First, from a technical point of view, it simplifies the problem. Secondly, in practice, banks would smooth out losses using provisions. The issue of a firm taking debt speculating with bank bankruptcy is interesting but left for future research.

Equilibrium Analysis

I now analyze the equilibrium outcome of the problem in equation 2.1, restricting it to the case in which $r = X - y$ (the firm that invests does not save) and to $S = y - r$ (the firm saves everything); a feature that is true in equilibrium ex post given the linearity of the problem.

Firm's Strategies

In period 2, firms will react optimally to the payments that the bank requires when deciding whether they will invest, store or gamble.

Incentive compatibility implies that the firm will invest as long as the profits of investing are higher than the profits of storing and gambling.

Given that the mean return of investing is higher, at low levels of debt the firm would always prefer to invest (conditional on having enough funds). It is also clear that at extremely high levels of debt, the firm would also decide to invest over storing. Since profits are decreasing in b, we can see that there will be two crossings of the profit functions.

The indifference between investing and storing will be when

$$E\pi^I \equiv \alpha(b)(\bar{y}-b+E(\epsilon|survival))+(1-\alpha(b))V^\ell = h(b)(y+S-b+E(\nu|survival))+(1-h(b))V^l \equiv E$$

If the bank extends fresh funds for the firm to invest, it will lend $r = X - y_1$ (thus keeping it at zero profits). If the firm instead decides to use the funds in storage, it will be able to save $S = X$. Therefore,

$$\alpha(b)(\bar{y}-b+E(\epsilon|survival))+(1-\alpha(b))V^\ell = h(b)(y+X-b+E(\nu|survival))+(1-h(b))V^l$$

Thus,

$$\bar{b}_j = \frac{h(\bar{b}_j)}{h(\bar{b}_j)-\alpha(\bar{b}_j)}(X+\Delta E(survival)) + \frac{h(\bar{b}_j)y\alpha(\bar{b}_j)\bar{y}}{h(\bar{b}_j)-\alpha(\bar{b}_j)} - V^\ell$$

which crosses twice at $h(\bar{b}_1) > \alpha(\bar{b}_1)$ and at $\alpha(\bar{b}_2) > h(\bar{b}_2)$. The incentive compatibility functions are plotted in Figure 2.6. For any b smaller than $\bar{b}_1$, the firm wants to invest. However, between $\bar{b}_1$ and $\bar{b}_2$, it is more profitable for the firm to store the funds, since liquidation probability is much smaller under storage. After $\bar{b}_2$, the firm prefers to invest or gamble since storing would not yield a high enough return to avoid liquidation.

For large b, investing is not likely to save the firm from bankruptcy. Since the loss function is truncated at $V^\ell < 0$, it becomes more profitable to gamble

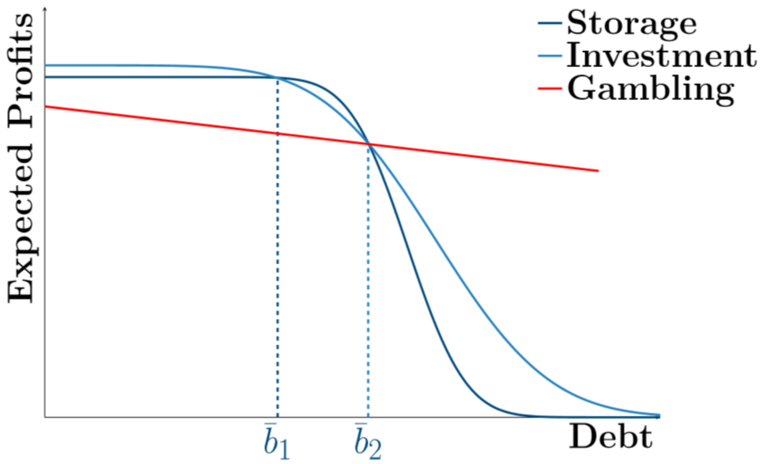


Figure 2.6 – Incentive Compatibility

at very high levels of b.[9] The plot in Figure 2.6 shows the expected profits from gambling starting at a lower point in the ordinate, given the inefficiency of such investment. The slope is small in absolute terms given the fact that, since the probability of success is small, for each increase in b, the expected payment of b increases only by γb.

Therefore, the firm's strategies are defined by

- If $r = y - X$, invest for all b lower than $\bar{b}_1$
- If $r = y - X$ store for all $b \in [\bar{b}_1, \bar{b}_2]$
- If $r = y - X$ gamble for all $b > \bar{b}_2$ (until outside option, $V^\ell < 0$)
- If $r < y - X$, store, as there are not enough funds to invest.

Bank's Strategies

There are only two possible strategies for the bank in terms of current required payment, r. The bank will either lend enough for the firm to invest, $r = X - y$, or take all the available funds, $r = -y$. Alternatively, it can be thought of the bank paying enough for the firm to be kept afloat ensuring zero net profits, $\pi = 0$, if the firm is making a loss, i.e $r = y_1 < 0$.

If the Bank funds investment,

$$\pi^B_{inv} = \alpha(b)b + (1 - \alpha(b))\ell - R(X - y_1)$$

The bank obtains b if the firm invests and is successful, or ℓ if the firm invests and is unsuccessful. It has to cover the costs of investment, which decreases its profits, $R(X - y_1)$.

[9]In the graph, the three lines intersect in the same point, $\bar{b}_2$. This is for exposition purposes. None of the results is dependent on this assumption.

The profit function grows at $\alpha + \alpha'(b - \ell)$ and it achieves a maximum at $b_{inv}^{Max} = \frac{\alpha}{-\alpha'} + \ell > \ell$. The following proposition characterizes the profit function of a monopolistic bank that can induce investment.

Proposition 2. *If investment is efficient and disruption costs are "low", then* $b_{inv}^{\max} > b^C$

The proposition states that, if unconstrained on the amount of funds that the bank can extract from the firm, it would take a higher share of the income by using the monopoly power than in the case of competition (Figure 2.7, left panel). However, for high enough b, the firm switches strategy and decides to gamble funds. This creates a sudden drop in the profit function that limits the amount to be extracted. This can be seen in the kink observed in the right panel of Figure 2.7.

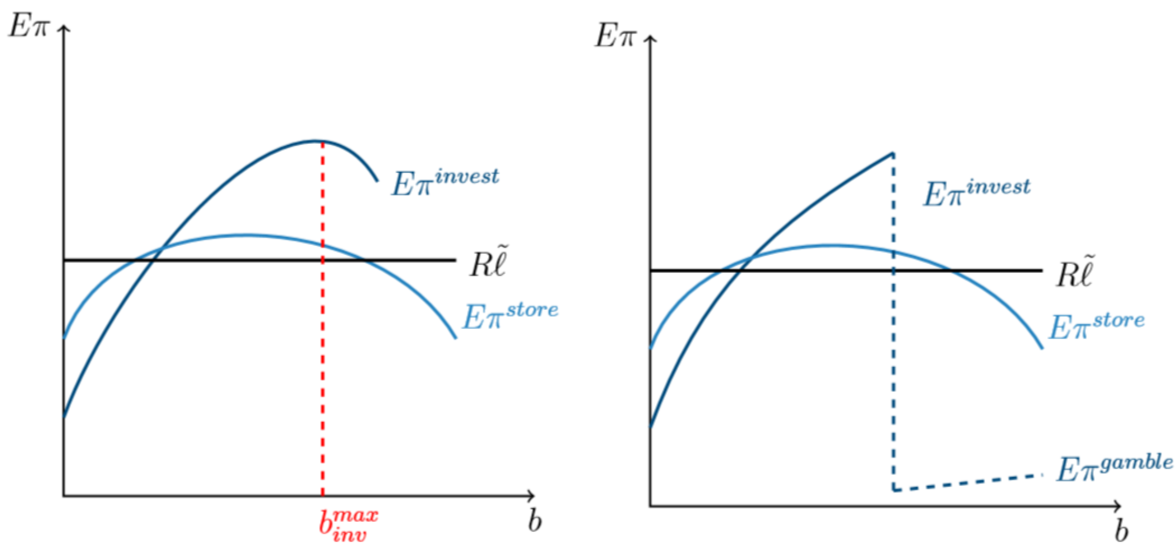


Figure 2.7 – Bank's Profit Functions

If, on the other hand, the bank decides not to fund investment,

$$\pi_{st}^B = h(b)b + (1 - h(b))\ell + Ry_1$$

The profit function for a bank that induces storage grows at $h + h'(b - \ell)$ and it achieves a maximum at $b_{store}^{Max} = \frac{h}{-h'} + \ell > \ell$.

If the possible b to be extracted is low, the bank prefers to have the firm store and save on the investment costs and risks. If the debt to be extracted is higher, the bank prefers to have the firm invest. In both cases, however, the profits must be weighed against the benefit of liquidating the firm.

If the bank decides to liquidate it will get,

$$\ell R Prob\left(\psi < K - f(A')\right) + \left(1 - Prob\left(\psi < K - f(A')\right)\right) V^B \equiv \tilde{\ell} R$$

where $b' < b_0$ is the remaining assets that the bank has in its book after liquidating the firm. This directly increases the likelihood of receiving a shock that will push the bank below capital requirements, $Prob\,(\psi < K - f(A'))$. The bank will receive the liquidation value of the firm (and interests on it) if it does not go bankrupt, and it will get its own bankruptcy value if it does. This is summarized in the following proposition.

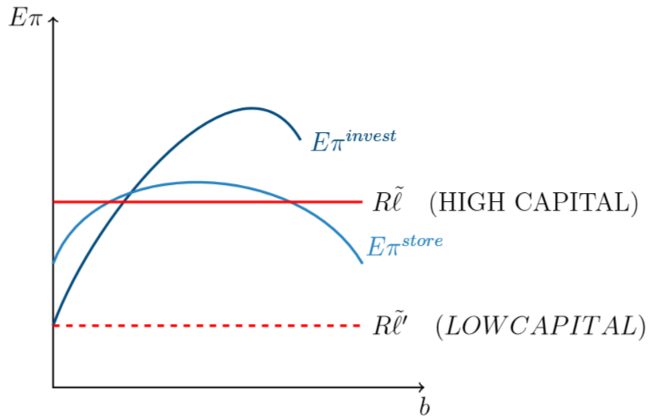


Figure 2.8 – Proposition 3

Proposition 3. *Bank's bankruptcy probability increases with firm liquidation. Bank's incentive to liquidate are decreasing in its assets.*

This implies that a highly capitalized bank that can extract very few funds from the firm does not risk its own bankruptcy by liquidating the firm, and finds it profitable to do so. If, however, the bank has low capital, the $R\ell$ curve moves downwards as the bank prefers not to liquidate. This is illustrated in Figure 2.8.

The relevant profit function for banks is the comparison of storing, investing and liquidating depending on the feasibility of b arising from the incentive compatibility of the firm. In other words, it can extract as much as possible from the firm as long as the firm has nonnegative profits and acts in its own interest. Figure 2.7 shows the profit functions for each action of the bank. If the bank can extract very low surplus from the firm, it would rather have the firm store funds and avoid bankruptcy. If the bank could extract very large funds from the firm, it would prefer the firm to invest. However, this is capped by the fact that a very high debt will make the firm use the fresh loans in non efficient investment (i.e, gambling).

2.4.4 Analysis

The literature on debt overhang claims that a firm in that situation, cannot obtain funds for investment. I begin by stating a proposition that is similar in the final outcome, but for slightly different motives.

Proposition 4. *When firms are in debt overhang, liquidation risk increases and efficient investment decreases. Social welfare decreases.*

When there is debt overhang problem, the amount of money that the bank can obtain from the firm is not determined by the opportunity cost, but it maximizes the amount of money that can be extracted from a firm. Therefore, the bank pushes the debt beyond the competitive level of debt. The high debt that the bank can get pushes the firm towards the region of their incentive compatibility in which it prefers, as it is too risky to invest, or gamble, as it is not enough to avoid bankruptcy with invest. Anticipating this, banks decide not to extend funds at all and investment does not take place. Social surplus is, in any case, lower in expected terms.

Unlike in Myers (1977), the motive here is not that the firm cannot access to alternative sources of funding, but the fact that the bankruptcy risk would make the firm act suboptimally if funds were extended to it.

The following two propositions enumerate the conditions under which evergreening takes place, and zombie firms arise.

Proposition 5. *(Zombie firms) If the firm is in debt overhang, the bank has "low" capital and investment is efficient but not highly profitable, the bank evergreens if*

1. *y is "large", or*
2. *ℓ is "large"*

The proposition shows the incompatibility between the incentives of banks and firms when there is a profitable investment opportunity that is very costly.

The first part of the proposition says that when profits are high on average but the firm is suffering a loss, the bank will provide funds to let the firm in zero profits and not let it go bankrupt. However, the bank will not provide further funds to invest. The reason is that, given the monopoly power, the bank can extract all funds from the firm tomorrow, y. If it extends funds for investment, and in order to make a profit, the bank needs to offer a higher debt level. However, the fact that a firm under such a high level of debt would not use the funds efficiently, and may instead gamble or store the funds, makes it impossible for the bank to obtain more. In normal circumstances, the bank would liquidate the firm. The low capital makes it risky to do so. Therefore, the bank evergreens and waits. A graphical interpretation is in Figure 2.9.

It is relevant to note that, when the debt level is between $\bar{b}_1$ and $\bar{b}_2$, the firm is not willing to invest, and thus would not demand any funds whatsoever even if given the chance. Moreover, if firms make a positive profit in the first period, and even if such profit is enough to fund investment, $y_1 > X$, firms would not want to invest and would instead hoard cash and repay debt under this

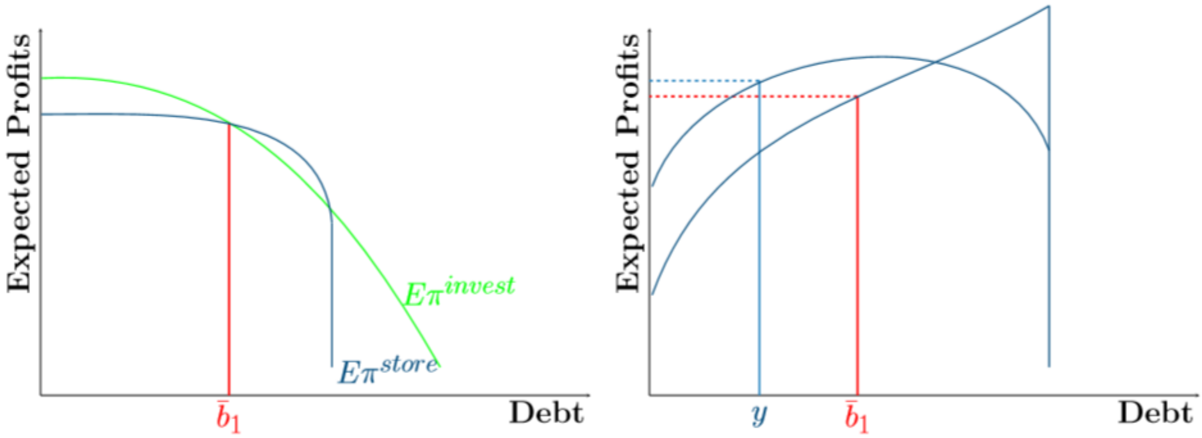


Figure 2.9 – Conditions for Zombie Lending

contract.

The second part of the proposition shows another situation in which zombie lending arises. In that case, the bank would like to liquidate the firm because the liquidation value is large. However, it is unable to do so because it would imply approaching its minimum capital requirements and endangering its own survival. The bank keeps the firm "hostage" by taking the cash flows without funding investment. In this way, the bank avoids the firm from breaking free in the case of a successful investment thus loosing the liquidation vale.[10] This firm would like to invest but the bank prefers to keep it until it can liquidate, obtaining as much as possible in the meantime.

The problem, in the second case, is an oversized firm (high liquidation value for low cash flows). This is consistent with Fukuda and Nakamura (2011), who analyze empirically why some zombie firms recover in Japan. They find that selling unused fixed assets was effective for the revival of troubled firms.

Policy Implications

Now I discuss several policies implications that arise from the model.

Proposition 6. *In a situation of debt overhang, it is welfare improving to do a debt haircut and redistribute firm's profits ex post.*

A debt haircut limits the capacity of the bank to extract funds from the firm. Provided the haircut is large enough, the firms can regain access to the competitive market and use the cheaper funds to invest, since the project is profitable. This increases the expected social surplus. Firms' profits can afterwards be taxed if investment is successful and distributed to the bank in the form of a

[10]This resembles to the concept of *Cash Cow*, which is jargon for a venture that generates a steady return of profits in a mature industry with a low expected growth rate.

subsidy. Risk is reduced, expected surplus increases and banks can be compensated, thus making everyone better off.

Proposition 7. *A "small" decrease in the interest rate in a situation of zombie lending does not increase investment.*

In normal times, decreasing the interest rate increases the incentive of the firm to invest. However, when firms are in debt overhang, if the firm has a negative cash flow, $y_1 < 0$, the bank has an incentive to provide evergreening instead of liquidating even if liquidating is socially and privately optimal. Decreasing R decreases the potential profit of liquidating a firm, $\tilde{\ell}R$, and decreases the opportunity cost of providing financial support to the firm, RX. At the same time, it also decreases the cost of providing funds for investment. The monetary policy needs to counterbalance the negative effect of the debt overhang and this requires a very large decrease in the interest rate. This explains the low elasticity of investment to interest rates without the need of the liquidity trap or the zero lower bound. In the presence of zombie firms, a small decrease in the interest rate without any debt haircut has no effect on investment and social welfare. The bank keeps the firm alive but it does not fund new investment, because the bank is able to use its monopolistic power to obtain a larger share of y in period two.

Proposition 8. *In the presence of zombie firms, mild recapitalization of banks lead to increased zombie lending. Large recapitalizations lead to increased efficient liquidation.*

In terms of Figure 2.7, a mild recapitalization decreases $R\tilde{\ell}$, but if the amount that can be extracted in an incentive compatible manner from the firms is low, the bank decides to evergreen and avoid gambling by the firms. To avoid disruption, it is necessary to couple capitalization of banks with debt renegotiation.

Another policy that was applied in practice that may be valuable in the context of zombie firms is to temporarily decrease capital requirements.[11] In the model, this induces the efficient liquidation of firms. Intuition is simple. When liquidation is efficient socially and privately, but undercapitalized banks are not willing to do it, relaxing the capital requirements will allow banks the ability to do it.

Finally, in the model, partial liquidation of the firm is desirable –consistent with the Japanese experience.[12] Partial liquidation decreases the incentives of the bank to keep firms under its power and thus they can start to lend for productive investment again.

[11] For example, in the aftermath of Argentina's crisis in 2001, several banks were sued by the public for their savings. The central bank allowed them to pay without writing them down in their books.

[12] See Fukuda and Nakamura (2011)

Capitalized Banks

Capitalized banks can, in principle, liquidate firms without worrying about going bankrupt. However, several other factors may induce a similar behavior to undercapitalized banks. Managers, for instance, do not want to show losses in order to gain bonuses, avoid panic from investors or keep the stock price high.

In some countries, regulation forbids banks from holding an equity position in the firms they are lending to. The findings in this paper would imply that, in those cases, more zombie lending would take place.

What if the borrower is a sovereign country? In this case, “liquidation” or “acquisition” is impossible. This setup would be similar to Kovrijnykh and Szentes (2007). They analyze Markov equilibria in a model akin to Albuquerque and Hopenhayn (2004)’s model of optimal firm lending contract extending it to two lenders. After a sequence of bad shocks the borrower enters in a debt overhang situation in which the incumbent lender has monopoly power over the firm. At that point, the lenders make the investment decisions. The key result is that even though the incumbents could keep these firms forever, they find it profitable to let the firm regain access to the market. My paper is similar when banks are capitalized but cannot liquidate the firm, because my focus is on firms and not on countries. A slight difference is that, in my model, the incentive compatibility of firms for their funds is central: they can either invest, gamble or store, and they care about their survival. In Kovrijnykh and Szentes (2007), the borrower has no choice, and the monopolist decides to underinvest.

Entrants

In this section I discuss the role of zombie firms on entrants. In Appendix B.1, I include entrants in stylized manner akin to Hopenhayn (1992) as in, for example Aragon (2017). The effect on the economy of keeping zombie firms alive is to reduce investment by deterring entry. Incumbent firms are stagnated and do not invest, and potential entrants that need to invest decide not to enter.

In this case, the social value of liquidating a firm is greater than the private value of liquidating a firm. The private value of liquidation is the market value of selling the firm’s assets, which can be either lower or higher than the value of the firm. In other words, liquidating a firm is not intrinsically inefficient. There is a social value of liquidation as well. As has been found empirically for the case of Japan, there are effects of incumbent firms -zombies- on deterring entrants (Caballero et al., 2008). The key point is that the externality is not taken into account by banks[13] since the entrant may start a lending relationship with the other bank instead of the incumbent.

[13] This can be seen as a special case of Greenwald and Stiglitz (1986).

In this way, the social value may be higher than the private liquidation value of the firm when it is socially desirable to liquidate firms. Banks do not take into account the externality because, even if they can liquidate the firm and open the market for new entrants, the new firm can start a lending relationship with either one of the bankers, decreasing the incentives of a single bank to liquidate a firm.

2.5 Discussion and Conclusion

Zombie lending is a phenomenon that has been observed in Japan, China, Spain and Italy, always after the burst of a bubble. This paper explains why zombie lending arises and continues to thrive, even when renegotiation is possible and efficient projects are available. The main driver of this result is that, after the burst of a bubble, the borrower is locked-in a lending relationship with its incumbent bank. The incumbent bank can then extract more funds than socially optimal from the firm, which ends up asphyxiated and with debt and no desire to invest. In particular, even profitable investment opportunities may not materialize.

The model captures a fundamental conflict between lender and borrower in a double decked incentive problem. The fact that both borrower and lender are near bankruptcy affects the way that they perceive costs and benefits. Firms may not be willing to use the fresh funds in efficient investment to avoid their liquidation, and the bank anticipates this. Particularly, the observed empirical fact that firms are not willing to borrow does not mean that they do not have profitable investment opportunities, but the fact that they may be too close to bankruptcy and optimally decide to store or repay debt.

Several assumptions are essential to obtain the results. First, debt contracts are non contingent. This means that the bank cannot make the payments conditional on realized profits or on actions taken. However, as long as the bank cannot observe perfectly the use of the funds by the firm, the results should hold. Second, some degree of bank opacity is necessary for the bank to continue to exist. Otherwise, investors would price the asset loss in the market value of the bank and it would go below the minimum capital requirements and then bankrupt. This relates to the discussion on whether to use market values for the banks' books, but more extensions should be done to have a broader idea of the effects.

The model not only fits the stylized facts in Japan, but is also consistent with Spanish data after the burst of the real state bubble. In next work, I am planning to use mergers as exogenous variations in bank capital, and to track the implications of these actions for investment and liquidation.

The model has non trivial policy implications, in stark contrast with common wisdom but in line with empirical research made for Japan and Europe.

Debt haircuts are shown, in the model, to be necessary to restore investment. Fukuda and Nakamura (2011) show empirically that debt relief and capital reduction were very important for zombie firms to recover in Japan.

The model also explains why bank capitalization is not enough to restore investment, as it only attacks one side of the incentive problem. This is consistent with Acharya et al. (2016) empirical observation in Italy. They showed that the increased price of sovereign bonds after massive buyouts by the ECB did in fact help recapitalize banks. However, the funds were directed to unprofitable firms.

Finally, the model explains the low elasticity of investment to the interest rate due to the existence of zombie firms without the need of the zero lower bound and thus the ineffectiveness of monetary policy. The policies enacted in Japan failed because they did not attack the underlying motives. Naturally, if the interest rate would decrease towards very low (negative) levels this would indeed increase investment. In other words, an increase in inflation in the presence of zombie firms would achieve two things simultaneously : (1) liquefy corporate debt and (2) decrease the real interest rate, assuming some price stickiness.

A caveat of the model is the lack of moral hazard and the quantitative response of the increase in the interest rate. Exploring these in a larger model seem like a fruitful venue for future research.

Chapter 3

Optimal Haircuts

3.1 Introduction

Massive government intervention is ubiquitous during episodes of crises. Intervention can take different forms and many of these be considered bailouts. Different ways of bailing out firms are subsidies to specific sectors, new lines of credit or simply buying assets of troubled firms. For instance the Troubled Asset Relief Program (TARP) required 700 billion dollars to provide credit to financial and non financial institutions during the Great Recession. Another widespread policy is general debt relief in the form of haircuts on deposits, as in Argentina 2001, Cyprus 2012 and Hungary 2012. In Argentina and Hungary, companies were indebted in foreign currency - US dollars and Swiss Francs respectively- and a sudden devaluation of the exchange rate pushed many of them into bankruptcy. In the case of Cyprus, there was a real shock in the form of a general downturn of economic activity that made the previous level of debt unsustainable.

There are opposing views as to whether it is efficient to intervene when the economy is hit by a large aggregate shock. Proponents of intervening argue that, if the government does nothing, the economy will go through a meltdown. Opponents, on the other hand, claim that intervention will not only fail to increase the level of activity but will also create perverse incentives for risk taking, which are detrimental for long run growth.

This paper studies the desirability of intervention in a simple model of heterogeneous firms and heterogeneous agents. Agents can be either entrepreneurs –who own the firms– or households –who lend to firms and supply labor. The main result of the paper is that there are conditions under which it is optimal to do a haircut of *all* the debt in the economy. This haircut effectively bails out troubled firms. The logic is as follows. No debt relief would imply massive bankruptcy and therefore a low wage income for the household, but a high income from loans. Complete debt relief would imply a low income for the households from their deposits but a high income derived from wages.

Partially bailing out troubled firms dampens the negative effect of the shock on output and employment but households also receive less income from their deposits. In this context, there are redistributive effects. In other words, there is a tension between maximizing output and maximizing welfare. The optimal haircut will not restore full potential output, but will maximize the mix of household income.

The baseline model is very simple. There are three periods and two types of agents: entrepreneurs and households.[1] Entrepreneurs own the firms and eat their profits. Households provide labor and lend to a competitive bank. In order to finance the firm's working capital, entrepreneurs borrow non-contingent claims from the households. These entrepreneurs have different productivities and consequently their firms have different debt positions. After taking a loan from the bank via the households, firms produce and pay wages and interest on their debt back to the households. Consumption takes place in the last period for both agents, but households also consume in the first period out of their endowment.

In normal times, firms produce and pay back their debt. Entrepreneurs consume their profits and households consume using their wage income and interest receipts. In this scenario, if a small unexpected aggregate shock hits the economy, entrepeneurs can still repay their debt out of their profits and avoid bankruptcy. All the risk is beared by the entrepreneurs, and households observe no change with respect to normal times.

In crisis times, with a large enough unexpected aggregate shock, the previously agreed structure of property rights is no longer sustainable. Low productivity firms go bankrupt. Others will reoptimize thus cutting down their production and deleveraging by reducing profits. The main result of the paper is that, under these circumstances, a redistribution from lenders to borrowers, even though not individually optimal, can be welfare improving. The economy can handle small shocks, but to cope with a large scale macroeconomic shock policy intervention is necessary.

I also show two equivalence results. First, the optimal haircut can be implemented through taxes. Secondly, the close economy result continues to hold in an open economy after a devaluation shock.

I extend the model to allow for firm entry in the spirit of Hopenhayn (1992). The dynamics is generated by repeating the three period model above infinite times. In the last subperiod of the three period structure presented above, there is also a mass of potential entrants that differ in their entrepreneurial spirit. They will attempt to enter if the expected payoff is positive. After deciding whether to enter or not, they get a random draw with their market

[1]As Aghion et al. (1999) claims, there are a number of reasons why households and entrepreneurs are different. First, becoming an entrepreneur requires ideas, specific skills or connections. Second, the presence of credit constraints and the individisibility of investment opportunities. Finally, government regulations may restrict the ability of certain social groups to invest in certain assets.

productivity and will enter if realized profits are positive. In the presence of a bailout the market wage is kept higher than when there is no such policy, thus increasing the cost of entering. This paper shows that there is an effect of bailouts that deters entrants. Depending on the distribution of the entering firms' productivities, it is optimal to bailout bigger firms and it is never optimal to bail out low productivity firms. Bailouts can have, even in the absence of moral hazard, effects on the distribution of productivity on the long term.

Section 3.2 frames the paper in the literature. Section 3.3 presents some historical accounts of debt haircuts. Section 3.4 presents the model, and discusses the effects of entry and devaluation shocks. Section 3.5 concludes and discusses.

3.2 Related Literature

There is a vast literature on bailouts to which this paper contributes. Since Bagehot (1878), and most notably with Diamond and Dybvig (1983), the focus has been on the role of lender of last resort of the government and focused on bailing financial institutions during speculative attacks. Allen and Gale (2000) analyze the case of systematic panic and insolvency. In this case, the bailout is an attempt to avoid credit freeze in the economy.

This work relates to several disjoint branches of the literature: bankruptcy, moral hazard, and firm entry.

Chari and Kehoe (2013) analyze firm bailout focusing solely on moral hazard and time consistency, and find that even if bankruptcies are costly it is still welfare improving not to take action in order to prevent future incentives to take risk. Bianchi (2014) provides a similar rationale. Contributing to this literature, Nosal and Ordonez (2013) show that if government does not have full information about the nature of the shock, there is an incentive to delay intervention that causes financial entities to strategically restraint from risky behavior. Uncertainty can be a substitute for government commitment not to bailout banks and thus ameliorates moral hazard considerations. Therefore, I abstract from incentives to take risks after the bailout.

Bankruptcy has been treated within the finance literature focusing mostly on conflicts of interest between different actors (e.g Bulow and Rogoff, 1986) and strategic decisions in a firms' choice between Chapter 7 and Chapter 11 and their investment decisions (e.g Berkovitch and Israel, 1998). In the macro literature, Corbae and D'Erasmo (2014b) provide a state of the art model with debt renegotiation and heterogeneous firms. They analyze the effect of bankruptcy law (Chapter 7 and Chapter 11) on the financial structure of firms. However, they do not analyze the transition or the distributive effects, which are the focus of this paper.

My setting builds on a very simplified version of the workhorse of heterogeneous firms, Hopenhayn (1992). This setup has been extended in many dimensions for several fields. More recently, Khan and Thomas (2011) present a dynamic stochastic general equilibrium model with heterogeneous firms and credit market imperfections. They quantitatively measure the effect of a financial shock that is amplified given these imperfections. Khan and Thomas (2011)'s model, however, neglects the role of entry or redistribution, which are central in my paper.

A more recent strand of the literature highlights the redistributive effects given by these bailouts, to which this paper contributes directly by addressing the issues of firm entry and the incompatibility of property rights.

Keister (2010) shows that a bailout provides entrepreneurs with insurance to bad shocks, and therefore it is optimal to provide it. In my model, it is optimal for the consumers to bail them out, even at an apparent loss.

Jeanne and Korinek (2013) analyze the trade-off between ex ante intervention -macroprodudential policy- which cannot be well targeted, and ex post intervention -such as bailouts- that can. The model relies on a financial amplification mechanism *à la* Kiyotaki-Moore. The trade-off is basically between stabilizing output and avoiding moral hazard. There is only one firm and there is no bankruptcy or firm entry. Bianchi (2014) provides a quantitative model of efficient bailouts taking into account these dimensions as well. In Bianchi (2014)'s model, bailouts restore balance sheets and mitigate the severity of recessions.

Fornaro (2013) focuses on the role of redistribution and debt relief. He presents a New Keynesian model where there are lenders and borrowers with different marginal propensities to consume. The redistribution creates an aggregate demand effect when the economy hits the zero lower bound. This boosts output to the point of causing a welfare gain from debt relief. My paper contributes to this literature directly. I discuss the supply-side effect of redistribution and thus the potential optimality of debt relief even when the economy does not hit the zero lower bound. In Fornaro (2013) a transfer is necessary to restore full employment. In my model there is no involuntary unemployment, but the optimum allocation after the shock does not need to be at the pre-shock level. Eggertsson and Krugman (2012) provide a model with a similar redistributive component.

My model focuses on two dimensions previously overlooked by the literature. Firstly, households are not the owners of the firms. Hence, a redistributive effect arises that creates a tension between increasing welfare and increasing output. A planner observes that transferring resources from households to firms will increase output, but the atomistic agents do not see any individual benefit from forgiving their debt and a free-rider problem arises that may impede renegotiation. Moreover, there are transaction costs associated with verifying the productivity of each firm and their true net worth. Some companies may have debt with other companies that may also be indebted. These costs create a massive informational problem that cannot be easily avoided. This would provide a rationale for the Argentinean or Cypriot experience.

Secondly, I focus on firm heterogeneity which affects firm entry and exit. It is well known that during crisis firm exit increases and firm entry decreases (Ottavieno, 2013; Lewis, 2009; Lee and Mukoyama, 2009; Siemer, 2013). Davis and Haltiwanger (1992) show that there is evidence that recessions indeed increase reallocation towards more productive firms. Nevertheless, the role of bailouts on entry and exit has not yet been studied and can have an effect over the long run productivity of the economy. The mechanism I propose in this paper is that by avoiding bankruptcy of low productivity firms, the government keeps resources in these firms and thus deters entry from new and potentially better firms. Schott (2013) finds that the current crisis in the US caused a jobless recovery. Moreover, he finds that the problem is insufficient entry of new firms, and proposes a mechanism based on lack of collateral to pledge. My model provides a different channel: namely, by keeping resources in low productivity firms this creates a new barrier of entry for new firms. Caballero et al. (2008) show that in Japan, where massive bailouts have taken place, there was a massive reduction of the profits for healthy firms, which discourages their entry and investment. They provide evidence that industries with a large presence of bailed out companies exhibit more depressed job creation and destruction, and lower productivity.

3.3 Haircuts in History

3.3.1 Cyprus 2012-2013

The European Crisis of 2008 impacted on its periphery in a calamitous way. In the case of Cyprus, its economy shrank by 1.67% in 2009 due to the fall in demand from its main trading partner, the EU, in the service sector (mostly tourism and transport). Unemployment rose and asset and land prices heavily declined. Several companies were stressed which put the banking sector under pressure due to impaired loans. Moreover, banks were also exposed to European assets, particularly Greek, which prices were severely damaged. Banks ended up receiving a haircut of 50% in 2011. To support the banking system, the Cypriot state requested a bailout from the European Union and Russia, with the promise to satisfy certain austerity measures that will fall on households. Local reaction to such austerity measures was negative, as it was seen as a transfer from households to companies.

3.3.2 Hungary 2012

At the beginning of the XXI century, Hungary seemed to be on the way of adopting the Euro by 2009. For several eastern European countries, there were sizable advantages for taking debt in foreign currency in terms of interest rates. Moreover, funds in local currency, the fiorint, were scarce, as the government cut back on lending programs. At the beginning, the risk of a sudden devaluation seemed low. Capital was flowing to Hungary as it was about to enter the Eurozone. The private sector was thriftily taking debt.

With the European crisis, from mid-2008 through 2009, the Swiss franc appreciated relative to the euro and the fiorint, thus making the ratio of non performing loans soar. A recession started, and unemployment started to increase.

Hungary's prime minister, Viktor Orban, tried several tactics to dampen the shock on the private sector. In 2013, the Hungarian government announced a special -below the market- forceful conversion of foreign debt into fiorints to relieve the debtors, while also providing euros to the banks. In this way, the burden was in fact transferred to consumers. Over 9 billion euros from the central bank's reserves were used for the haircut.

Banks suffered large losses. According to Torok, a central bank economist, *"But it is not like somebody is winning. Everybody is losing. The private sector is losing. The government is not winning."*

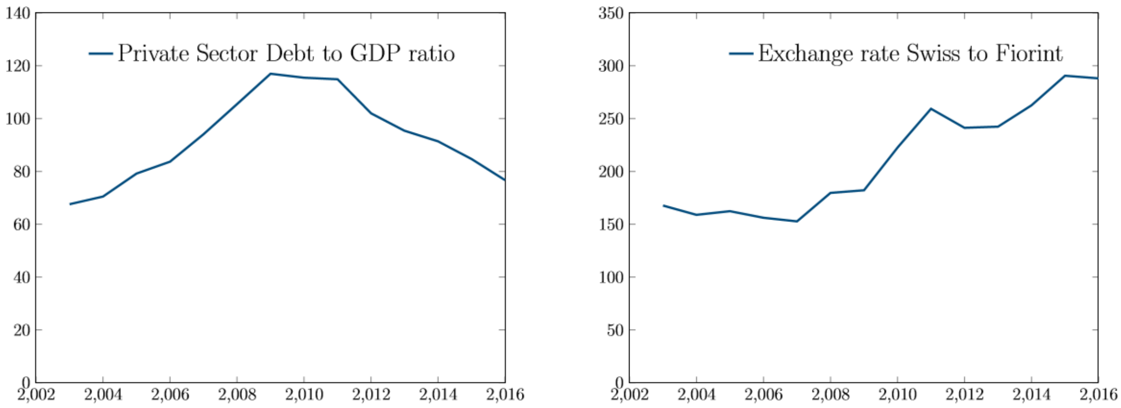


Figure 3.1 – Devaluation of Fiorint to Swiss Franc (Panel B) and Private Sector Debt in Foreign Currency (Panel A)

3.3.3 Argentina 2001

In the early 90s, Argentina successfully contained hyperinflation via a "Convertibility Plan" in which one peso would be worth one dollar. In this way, inflationist expectations were tamed. Moreover, in 1995 the Mexican crisis caused a stampede against emerging market assets and the Argentinian government successfully kept the parity. Government showed great commitment in keeping the system and boosted confidence even more. The banking sector became dollarized and the private sector borrowed and lent heavily in dollars.

However, the government kept on spending using debt as funding. In the late 90s, doubts on the ability of the government to keep the parity started to arise. A ban on withdrawing large amounts of money was established ("el Corralito") which increased doubts and caused riots on the street.

After having five presidents in a week, the government decided to finish the Convertibility Plan and let the peso float, starting at a parity of 1.4 pesos per dollar. However, it quickly depreciated to 3 pesos per dollar. Inflation was relatively contained, thus the peso heavily depreciated in real terms.

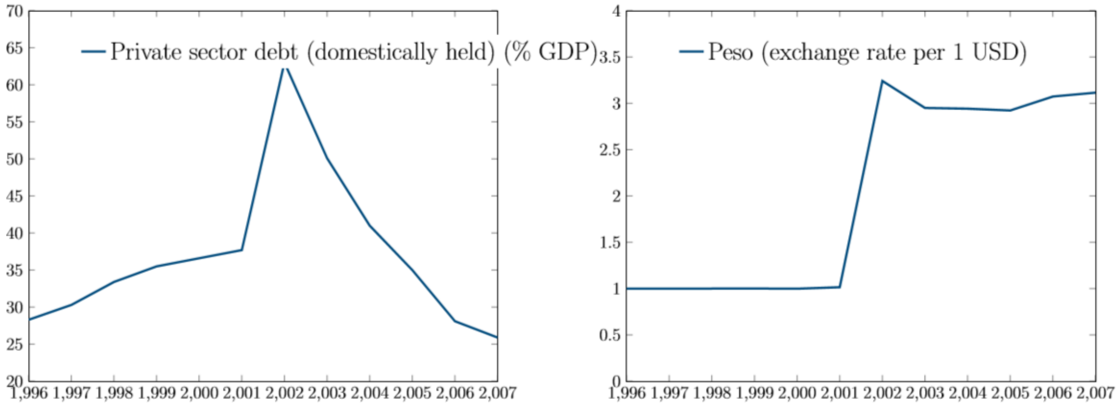


Figure 3.2 – Devaluation of Argentinian Peso (Panel B) and Private Sector Debt in Foreign Currency (Panel A)

As can be seen from Figure 3.2, debt spiked with the devaluation. Firms became financially distressed, as now their income was in devalued pesos and their debts still in dollars. Households had their time deposits also in dollars. The government decided on an "asymmetric pesification" , in which all debts with the financial system were transformed in to pesos at 1 peso per dollar, whereas the deposits in foreign currency would be recognized at \$1.40 pesos per dollar. To make up for the losses of the bank, the federal government funded the banks, thus transferring the burden to the households via taxes.

3.4 The Model

In this section we describe the basic model that captures the main theoretical insights of the effects of bailouts on redistribution and firm entry. The first subsection describes a simple three period model. In particular, we show that that a large macroeconomic shock may induce an inconsistent property right structure that can be solved by an optimal haircut on deposits. This haircut decreases firm bankruptcy on the one hand and therefore entrepreneurs are better off. On the other hand it also increases households income by decreasing the loss from their wage income that arises from firm bankruptcy. The next subsection lays out the dynamic model in which there is firm entry in a similar fashion to Hopenhayn (1992) but with a discrete number of firms. We show in this setting that firm entry is decreased by a bailout. By keeping firms in the market, resources are kept in this firms and entry costs are thus higher for potential entrants. This impedes the entry of potentially better firms. Finally, we provide equivalence results for taxes and an open economy.

3.4.1 No Entry

The economy lasts for three periods denoted by $t = 0, 1, 2$ and there is only one consumption good. There are two types of agents: entrepreneurs and households. Entrepreneurs own firms that differ in their productivity and produce the same homogeneous good in a competitive market. There is also a competitive bank that canalizes savings from the households to the firm and makes zero profits. There are two states of the world: "crisis" and "non crisis" . The "crisis" state is a zero measure probability event.

Entrepreneurs own the firms and eat their profits. They also borrow non contingent claims from the bank to finance their working capital. Households provide labor to firms and lend to a competitive bank. Entrepreneurs have different productivity and consequently their firms have different debt positions. After taking a loan from the bank via the households, firms produce and pay wages and interest on their debt back to the households. Consumption takes place in the last period for both agents, but households also consume in the first period out of their endowment.

The timing of the model is in Figure 3.3.

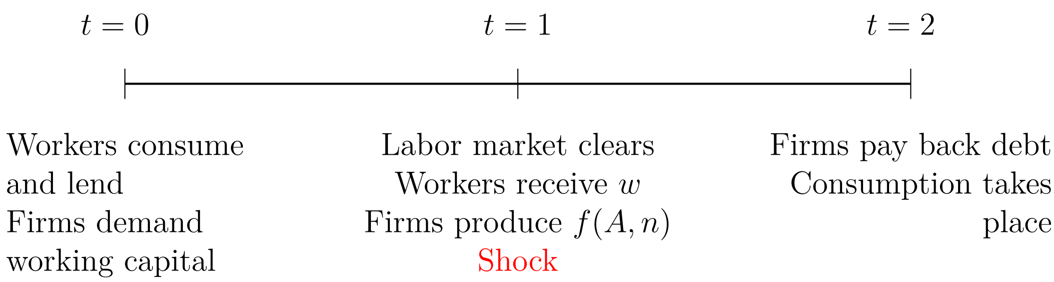


Figure 3.3 – Timing of the model

Households. There is a representative household with lifetime utility

$$U = E\{u(c_0) + u(c_2^S) + v(1 - n)\}$$

where c_t and n denote consumption in period t and labor supply respectively. Superscript S denotes aggregate state, which can be "crisis" or "non crisis" symbolized by superscripts ϵ and $\star$ respectively. Note that the household only consumes in periods 0 and 2. I assume that $u(\cdot)$ is strictly increasing, strictly concave, twice continuously differentiable and satisfies Inada conditions. I also assume that $v(\cdot)$ is strictly increasing and strictly convex.

In period 0, the household is endowed with an exogenous amount of the consumption good Taking the interest rate as given, he decides how much to lend to the bank and how much to consume in period 0. His budget constraint in period 0 is therefore given by

$$c_0 = y - b^S$$

where y represents the endowment and b represents the bank deposit. Deposit has the S superscript but since the shock is of zero measure, the agent will only choose $b^S = b^\star = b$.

In period 1 the aggregate shock is revealed, and the agent supplies labor and receives a wage income depending on which state happened. No consumption takes place in this period and wage income is costlessly moved from period 1 to period 2.

In period 2 the bank repays the deposit and the interest rate back to the household. Consumption takes place and is financed by the capital gain from the households and the wage income. The budget constraint in period 2 then reads

$$c_2^S = w^S n^S + b^S(1+r)$$

where w denotes wage and r the interest rate received from the bank. The S superscript is due to the fact that when the aggregate state is ϵ both equilibrium wage and repayment from the bank will be different. This follows from possibility of some firms going bankrupt thus decreasing aggregate labor demand and repayment to the bank. All this changes the optimal choices c and n. Note that the interest rate is not contingent. Budget constraints in each case are therefore

$$\begin{aligned} c_2^\epsilon &= w^\epsilon n^\epsilon + b^\epsilon(1+r^\epsilon) \\ c_2^\star &= w^\star n^\star + b^\star(1+r) \end{aligned}$$

In sum, the household solves

$$\begin{aligned} \max_{c_0,n,b} U &= E\big\{u(c_0) + u(c_2) + v(1-n)\big\} \\ s.t \quad c_0 &= y - b \\ c_2^\epsilon &= w^\epsilon n^\epsilon + b^\epsilon(1+r^\epsilon) \\ c_2^\star &= w^\star n^\star + b^\star(1+r) \end{aligned}$$

Entrepreneurs. There are three entrepreneurs that differ in their productivity. Each one of them owns a firm and produces the same consumption good using their productivity. Profits for a firm-entrepreneur of productivity z are denoted by π_z. Productivity can take three values $z \in \{z_l, z_M, z_H\}$ with $z_H > z_M > z_L$.

In period 0 firms take debt from the bank to pay for the wage bill of workers in period 1,

$$b_z^S = E(w^S n_z^S)$$

where n_z^S and b_z^S represent the labor demand and bank debt from a firm-entrepreneur with productivity z in aggregate state S.

In period 1 firms produce and hire workers in a competitive labor market. In period 2 they pay back their debt and consume their firm's profits. They have a utility function $H(\pi_z)$ that is linear. They have a small outside opportunity of O which is normalized to 0.

The profit function of a firm with productivity z is thus given by

$$\pi_z = E\left\{A^S f(z,n_i) - (1+r)b_z^S - w^S n_z^S + b^S\right\}$$

where A^S represents the aggregate shock that directly affects productivity.

The production function satisfies **A1**.

Assumption 1. ***(A1)*** *The production function has the following properties*

- $f(\cdot)$ *presents decreasing returns to scale and is continuously differentiable,*
- $f(\cdot)$ *is increasing in* z*,*
- $\frac{\partial f_i(\cdot)}{\partial z} > \frac{\partial^2 f_i(\cdot)}{\partial N \partial z}$

The first two assumptions are standard and ensure the existence of equilibrium with competitive firms. The second assumption simply states the more productive firms produce more, given inputs. The third property is central in our analysis. This property states that larger firms use labor more efficiently. In other words, the bigger firms use proportionately less resources than smaller firms.

In other words, the firm-entrepreneur maximizes profits subject to their working capital constraint and non negative profits. The entrepreneur consumes their profits that are not necessarily zero given decreasing returns to scale and heterogeneous productivity. If profits are negative, the entrepreneur takes the outside option and declares bankruptcy.

The problem reads

$$\begin{aligned}
t=0: &\quad b_z^S = E(w^S n_i)\\
t=1: &\quad \Pi_i = \max\left\{0, \max_{n_i} E\left\{A^S f(z_i,n_z^S) - (1+r)b_z^S - w^S n_z^S + b^S\right\}\right\}\\
s.t &\quad w^S n_z^S \leq b_z
\end{aligned}$$

Lastly, I assume the presence of disruption costs when firms go bankrupt.

Assumption 2. ***(A2,*** *"Disruption Costs") When a firm decides to stop operating, a proportion* ϕ *of the firms' financial assets are lost.*

In other words, part of the money that the firm borrowed from the bank is lost when a firm declares bankruptcy. This is very well documented in the literature (Corbae and D'Erasmo, 2014b).

Proposition 1. *Given the previous set of assumptions, the indirect profit function satisfies the following,*

- $\pi_z(w^\star, r^\star|z_i)$ *is increasing in* z
- $\frac{\partial f(z_i,n_z^\star)}{\partial z} > 0$

- $\frac{\partial \pi_z(\cdot)}{\partial z} > \frac{\partial b_z(\cdot)}{\partial z}$

The first result simply states that profits are increasing in productivity. The second result states the more productive firms are larger in equilibrium. The last result says that profits increase faster with productivity than debt, so larger more profitable firms have lower profit-to-debt ratios.

Banks. There is a unit measure of banks. Banks are perfectly competitive and make zero profits. They accept deposits from households and canalize them into loans for the firms. When firms go bankrupt they seize their remaining assets –retrieved loans minus disruption costs– and repay households.

Laissez-Faire Equilibrium

In this section I define and characterize the equilibrium. The world is ruled by a random variable $S \in \{\epsilon, \star\}$ that corresponds to two possible states of the world, "crisis" and "non crisis" respectively. The aggregate shock A^S can take two values $\frac{1}{\xi}$ and 1 with $\xi \in \left[1, \bar{\xi}\right]$. The shock is taken to be of zero measure and is revealed in $t = 1$. In this way the information structure is such that households do not know the value of the shock when deciding how much to lend and firms do not know it when deciding how much debt to take. Entrepreneurs do know, however, the value of the shock when deciding how many workers to hire and much to produce.

Normal Times. On account of the zero measure shock, households and firms make decisions as if $A^S = 1$ with certainty. Hence they make non contingent decisions and subscripts with the state are omitted.

Definition 2. *An equilibrium in normal times is an allocation* $\{c_0^\star, c_2^\star, n^\star\}$ *and prices* $\{w^\star, r^\star\}$ *such that*

- *Given prices, the policy functions of the households,* $n(w^\star, r^\star)$ *and* $b(w^\star, r^\star)$ *maximize their utility*
- *Given prices and expectations, firms maximize profits by demanding* $n_z^d(w^\star, r^\star|z_i)$ *and* $b_z(w^\star, r^\star|z_i)$
- *Markets clear,*

$$n(w^\star, r^\star) = \sum_i n_i^d(w^\star, r^\star|z_i) \tag{3.1}$$

$$b(w^\star, r^\star) = w^\star n^\star \tag{3.2}$$

Households make labor supply and savings decisions. Firms borrow to finance working capital, pay wages, produce and pay back debt. In normal times these expectations are validated. Firms make non-negative profits because of the outside option and decreasing returns to scale.

Crisis Times. The crisis is modeled as an unexpected aggregate shock of size $\xi > 1$ that arises in $t = 1$. In this way, firms know the shock before hiring workers and starting production but not before taking debt to finance their working capital. Before defining the equilibrium we must note that depending on the size of the shock different outcomes are possible. The effective productivity for each firm is $\frac{1}{\xi} f(z_i, \cdot)$. Entrepreneurs have an outside option and do not internalize the disruption costs, so they will opt to go bankrupt if profits are negative. Since entrepreneurs differ in their productivity, different firms will decide to leave depending on the magnitude of ξ. Proposition 2 summarizes these outcomes.

Proposition 2. *There are three cutoffs $\bar{\xi}_0 < \bar{\xi}_1 < \bar{\xi}_2$ such that*

- *For a small shock, $\xi < \bar{\xi}_0$ all firms make positive profits.*
- *For an intermediate shock $\xi \in \left[\bar{\xi}_0, \bar{\xi}_1\right]$ low productivity firms exit and intermediate and high productivities firm stay.*
- *For a large shock $\xi \in \left[\bar{\xi}_1, \bar{\xi}_2\right]$ low and intermediate firms exit, while high productivity firms stay.*

They cut down employment, pay back their debt and have profits equal to $\pi(\hat{w}|Az) - rb$.

Firms have too much debt compared to their desired production and they re-optimize given the new values of productivity . The following proposition summarizes this

Definition 3. *The equilibrium in **crisis times**, is such that*

- *Firms re optimize and get $\pi_z^\epsilon = \max_{n_i} \{\epsilon f(A_i, n_i) - w n_i\}$ and demand labor*
$$n_i^d(w^\epsilon|A_i) = \begin{cases} argmax_{n_i} \Pi_i^\epsilon & \text{if } \Pi_i^\epsilon > r^\star b_i^\star \\ 0 & \text{if } \Pi_i \leq r^\star b_i^\star \end{cases}$$
- *If firms exit, they repay $(1 - \psi) b_i$*
- *Labor market clears ,*
$$n^s(w^\epsilon) = \sum_i n^d(w^\epsilon|A_i) = n^\epsilon$$
- *Agents consume $w^\epsilon n^\epsilon + (1 + r) b_i^\epsilon + (1 - \psi) b_j^\epsilon$ where i are firms that stayed in the market and j are firms that exited the market.*

Pareto Problem

The main difference between the planner problem and the decentralized equilibrium is that a planer would not use $b^\star$ as a constraint. Assuming the planner has a utilitarian welfare function with transferable utility within groups and a bankruptcy utility for entrepreneurs of $V\ell < 0$, the following proposition summarizes the result

Proposition 3. *The planner problem,*

- *In Normal times, coincides with the competitive equilibrium;*
- *In Crisis times, no firm goes bankrupt, but they decrease their size.*

Since firm productivity is still positive, it is efficient to have all firms operating after the shock passed. The planner prefers to keep all firms in the market but decreases their scale given their now lower productivity.

It is easy to see that a costless renegotiation between each firm and each bank, with perfect information would lead to the same outcome as the planer problem in crisis times.

Second Best Policy

The Pareto problem, that can be achieved in a decentralized manner with renegotiation may not be attainable. There are two main reasons for this: transaction costs and externalities.

Transaction costs are associated with verifying the productivity of each firm and their true net worth. Some companies may have debt with other companies that may also be indebted and so on and so forth. Recognizing which firms are solvent and which are not is no easy task. There is a massive informational problem that involves substantial transaction costs.

There is also an externality which is basically a free rider problem. A planner observes that transferring resources from households to firms will increase output, but the atomistic agents do not see any individual benefit from forgiving their debt.

The following proposition summarizes the central result concerning haircuts from this paper,

Proposition 4. *(Optimal Haircuts). Given a shock $\xi \in \left[\bar{\xi_1}, \bar{\xi_2}\right]$, there is an optimal debt haircut ϕ for every firm in the economy; such that low productivity firms go bankrupt but medium productivity firms stay in the market. Both consumers and entrepreneurs are better off. The policy does not restore full employment. Moreover, the policy can be implemented also by taxes on profits.*

The intuition is the following. Full debt forgiveness leaves agents with little income from their lending but maximum production. No debt forgiveness at all leaves agents with income from their lending (minus the disruption costs) but little output -and thus a low wage mass. An intermediate bailout saves intermediate firms if small firms are relatively smaller, and if intermediate firms

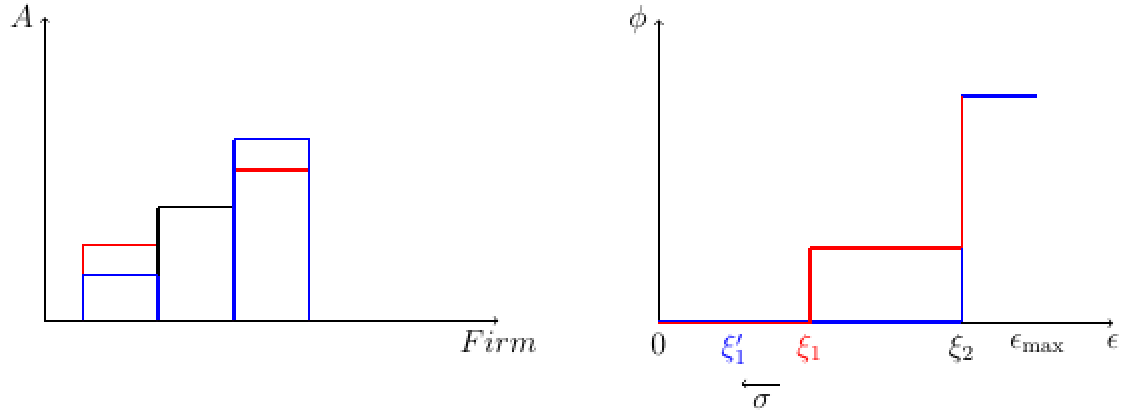


Figure 3.4 – Characterization of Optimal Haircut

are relatively bigger.

Figure 3.4 shows the behavior of the optimal haircut for different distributions of the firm's productivity. When the productivity is similar across the three types of firms, the optimal haircut becomes positive at ξ_1, which is the shock that puts the low productivity firm into bankruptcy. This is because the information asymmetry is not so important, given that most firms are similar. When the distribution of productivity becomes more unequal, saving the small firm implies a large transfer to big firms. Therefore, it is optimal to let the small firm die and the haircut would be activated only for really large shocks, that would put the intermediate firms at risk.

3.4.2 Devaluation Shocks

Note that there is an equivalence between a devaluation shock that increases rb relative to profits and a productivity shock that decreases output. Call e the exchange rate and ω the share of firms of type i that sell tradable goods. This is relevant for the cases of devaluation shocks given that an entrepreneur may suffer a devaluation shock in its debt but that is offset by its profitability shock. The entrepreneur's problem reads

$$\begin{aligned}
t = 0: \quad & b_z^S = E(ew^S n_i) \\
t = 1: \quad & \Pi_i = \max\left\{0, \max_{n_i} E\left\{A^S f(e, \omega_i, z_i, n_z^S) - (1+r)b_z^S - w^S n_z^S + b^S\right\}\right\} \\
s.t \quad & w^S n_z^S \leq b_z
\end{aligned}$$

Where the wage bill is paid in national currency, debt is denominated in for-

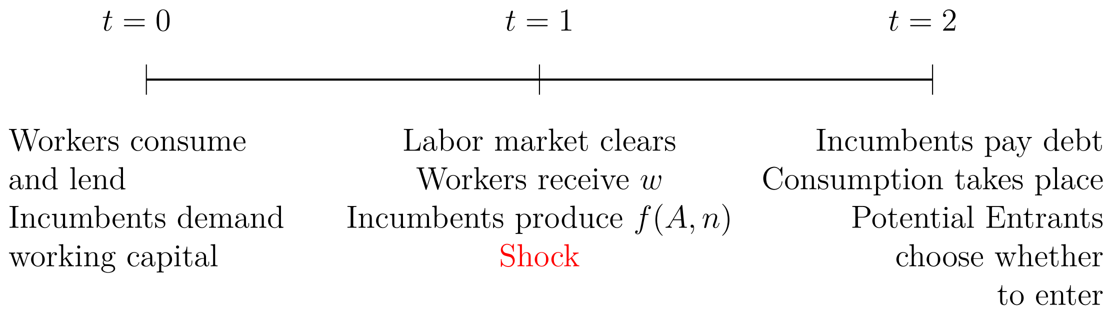


Figure 3.5 – Timing of the model with Entry

eign currency, and firm's profitability is affected by the exchange rate. This captures the fact that there are companies offering tradables and non tradable goods. The following result captures the equivalence,

Proposition 5. *Assuming the ω_i is increasing in z_i, there is a distribution, $\{Z_i\}_{i\in\{L,H,M\}}$ that Proposition 1 and Proposition 2 hold.*

In other words, it is possible to collapse the augmented tradables-non tradables and devaluation shocks into a new profitability distribution that includes the fact that some companies may sell in foreign denominated currency.

3.4.3 The Effects on Entry

Time will be discrete and indexed by $T = 1, 2, \ldots$. Each period T is composed of three different subperiods with the same structure as in the previous section. There is a pool of potential entrants that decide whether to enter or not in the last subperiod . If they decide to enter and have a successful, they become incumbents in the next period $T+1$, and make decisions just as in the previous case. The timing is in Figure 3.5.

The modeling of entry simplifies Hopenhayn (1992) and extends it to allow for insufficient entry.

There is an infinite and discrete number of entrants, $H = 1, 2 \ldots$. Each entrant has to pay a cost wc_e^i to know the productivity of their idea. I interpret $c_e^i \in \mathscr{C}$ as entrepreneurial spirit. This is in terms of the current wage, accounting for the opportunity cost of the entrepreneurs. Moreover, the entrants are ordered so that $c_e^1 < c_e^2, \cdots < c_e^{h-1} < c_e^h < \ldots$.

They will enter if the expected benefits of entering outweigh the costs,

$$V^e \equiv \sum_{i:\pi^i>0} E(\pi^i) > wc_e^i$$

In other words, the potential entrants pay an entry cost of c_e^i in terms of units of labor and take a productivity draw from the distribution ν, with $\sum_i \nu_i + \nu_o = 1$

and every element being positive. ν_0 is the probability that the idea is unproductive and the entrepreneur finds it unprofitable to enter the market.

Assumption 3. ***(A3)***

- *In the equilibrium without the aggregate shock, the incumbent firms are in equilibrium and there is no entry. In other words, without the shock we have* $V^e < w^\star c_e^1$
- $E(\nu) > \inf Z$

The first assumption is needed to focus on no firm exit in equilibrium.[2] The second part of the assumption simply states that an entrant has an average productivy greater than the smallest firm in the market.

The following proposition summarizes the results on bailout and firm entry.

Proposition 6. *A bailout on a low productivity firm decreases the average productivity over the long term.*

Basically the proposition shows that, when bailing out a small firm, this interferes with the cleansing aspect of recessions. This result is partially driven by the granularity in the distribution of firms. Carvalho and Grassi (2015) extends Hopenhayn (1992) to allow for a non ergodic distribution of firms. Analyzing whether this results hold in such a setup is part of the agenda for future research.

3.5 Conclusions and Further Research

This paper introduces an rationale for the optimality of haircuts that relies on redistributive effects. In other words, the tension between maximizing welfare and maximizing output. The model is stylized and simple which comes at the expense of realism.

The model presents a rationale for the Argentinean, Hungarian and Cypriot experience, although an empirical exercise calibrating a model to these countries would allow to see whether the *level* of the debt relief was accurate. A fully fledged framework to analyze this question is Khan and Thomas (2011). This paper needs to be enlarged with a proper treatment of the entry decisions and heterogeneous agents, before studying the transition with and without policies. This quantiative work adapted to the Argentinian 2001 crisis and pesification is developed in Aragon and Forero (2017).

A model with entry highlights an overlooked effect of bailouts on long term productivity. It can potentially explain the low entry in the US and Japanese economies during the Great Recession and the last two decades, respectively. The mechanism relies on the granularity of entrants as in Carvalho and Grassi

[2]This assumption can be easily relaxed in a more complex model.

(2015). A quantitative exploration within this framework will be explored in future research.

Appendix A

A.1 Robustness Checks

Table A.1 – Regression results of Equation 1.7 using $\sigma_{m,t}$ in stead of $\sigma^m_{m,t}$.

	Δp_t				
	(I)	(II)	(III)	(IV)	(V)
Δp_{t-1}	0.33^{***}	-0.24	-0.26	-0.17	-0.22
	(0.07)	(0.22)	(0.20)	(0.20)	(0.23)
$p_{t-1} - f_{t-1}$	-0.29^{***}	-0.25^{***}	-0.29^{***}	-0.26^{***}	-0.28^{***}
	(0.05)	(0.05)	(0.04)	(0.05)	(0.06)
σ_t	-0.96^{*}	-0.65	-0.88^{*}	-0.96^{*}	-1.85^{**}
	(0.44)	(0.44)	(0.42)	(0.41)	(0.58)
ΔE_t		0.60^{**}	0.29	0.69^{**}	0.89^{**}
		(0.21)	(0.21)	(0.25)	(0.27)
N_t			-31.57^{***}	-26.35^{***}	-17.25
			(7.32)	(7.34)	(9.09)
$E_{t-1} - p_{t-1}$				-0.58^{**}	-0.69^{**}
				(0.20)	(0.23)
Session FE					✓
Market FE					✓
Round FE					✓
Num. obs.	138	138	138	138	138
R^2	0.31	0.35	0.43	0.47	0.58
Adj. R^2	0.30	0.33	0.41	0.44	0.49

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table A.2 – Regression results of Equation 1.7 using $\sigma_{m,t}$ in stead of $\sigma^{m}_{m,t}$, using only observations from before a crash.

	Δp_t				
	(I)	(II)	(III)	(IV)	(V)
Δp_{t-1}	0.43^{***}	0.19	-0.01	0.05	-0.17
	(0.08)	(0.20)	(0.19)	(0.18)	(0.22)
$p_{t-1} - f_{t-1}$	-0.12^{***}	-0.11^{***}	-0.15^{***}	-0.12^{***}	-0.09
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
σ_t	-0.96^{**}	-0.85^{*}	-0.78^{*}	-0.84^{**}	-1.43^{**}
	(0.33)	(0.34)	(0.31)	(0.30)	(0.48)
ΔE_t		0.24	0.03	0.32	0.45^{*}
		(0.18)	(0.17)	(0.20)	(0.22)
N_t			-26.45^{***}	-25.19^{***}	-17.68^{*}
			(5.70)	(5.55)	(6.86)
$E_{t-1} - p_{t-1}$				-0.47^{**}	-0.44^{*}
				(0.17)	(0.20)
Session FE					✓
Market FE					✓
Round FE					✓
Num. obs.	105	105	105	105	105
R^2	0.28	0.29	0.42	0.46	0.59
Adj. R^2	0.26	0.27	0.39	0.43	0.46

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

A.2 Instructions for experiment

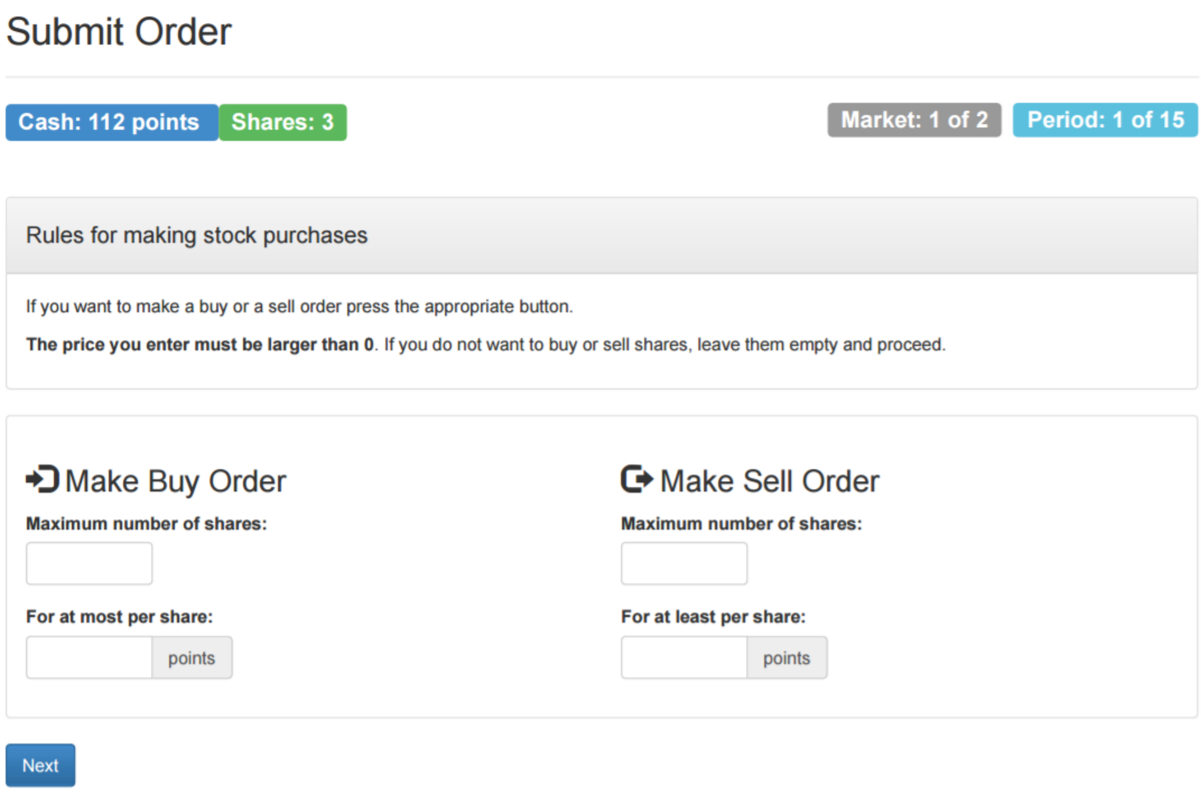
A.2.1 General Instructions

This is an experiment in the economics of market decision making.[1] The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The experiment will consist of two sequences of 15 trading periods in which you will have the opportunity to buy and sell in a market. The currency used in the market is "points". All trading will be in terms of points. The cash payment to you at the end of the experiment will be in euros. The conversion rate is 85 points to 1 dollar.

A.2.2 How to use the computerized market

General Instructions for asset trading

In each period, you will see a computer screen like the one shown below.



You can use the interface to buy and sell Shares. At the top of your computer screen, in top left corner, you can see the Money and Shares you have available.

[1] These instructions are those from Haruvy et al. (2007), with an added section explaining the novel forecast tool, and a different mechanism to deliver the payment.

At the beginning of each trading period, if you wish to purchase shares you can send in a buy order. Your **buy order** indicates the number of shares you would like to buy and the highest price that you are willing to pay. Similarly, if you wish to sell shares, you can send in a **sell order**. Your sell order indicates the number of shares you are offering to sell and the lowest price that you are willing to accept. The price at which you offer to buy must be less than the price at which you offer to sell. The price you specify in your order is a per-unit price, at which you are offering to buy or sell each share. In each period you can, if you wish, do simultaneously a buy and a sell order at different prices.

The computer program will organize the buy and sell orders and uses them to determine the **trading price** at which units are bought and sold. All transactions in a given period will occur at the same trading price. This will generally be a price where the number of shares with sell order prices at or below this clearing price is equal to the number of shares with buy order prices at or above this clearing price. The people who submit buy orders at prices above the trading price make purchases, and those who submit sell orders at prices below the trading price make sales.

Example of how the market works: Suppose there are four traders in the market and:

- Trader 1 submits an offer to buy at 60
- Trader 2 submits an offer to buy at 20
- Trader 3 submits an offer to sell at 10
- Trader 4 submits an offer to sell at 40

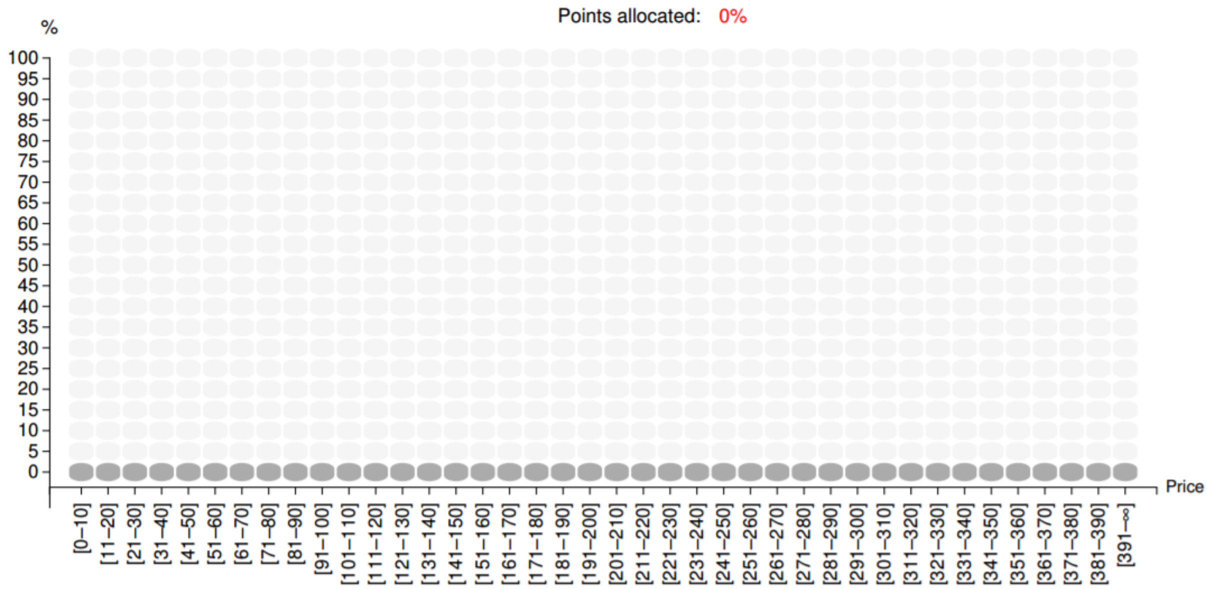
At any price above 40, there are more units offered for sale than for purchase. At any price below 20 there are more units offered for purchase than for sale. At any price between 21 and 39 there is an equal number of units offered for purchase and for sale. The trading price is the lowest price at which there is an equal number of units offered for purchase and for sale. In this example that price is 21. Trader 1 makes a purchase from trader 3 at a price of 21.

Specific Instructions for this Experiment

The experiment will consist of two independent sequences of 15 trading periods. In each period, there will be a market open, operating under the rules described above, in which you are permitted to buy and sell shares.

Shares have a life of 15 periods. Your shares carry over from one trading period to the next. For example, if you have 5 shares at the end of period 1, you will have 5 shares at the beginning of period 2.

You receive dividends for each share in your inventory at the end of each of the 15 trading periods. At the end of each trading period, including period 15, each share you hold will pay you a dividend of 0, 4, 14, or 30, each with equal



chance. This means that the average dividend for each share in each period is 12. The dividend is added to your money balance automatically after each period. After the dividend is paid at the end of period 15, the market ends and there are no further earnings possible from shares in the current market.

A new 15-period market will then begin, in which you can trade shares of a new asset for 15 periods. The amount of shares and money that you have at the beginning of the new market will be the same as at the beginning of the first 15 period market. There will be two 15 period markets making up the experiment.

Making Predictions

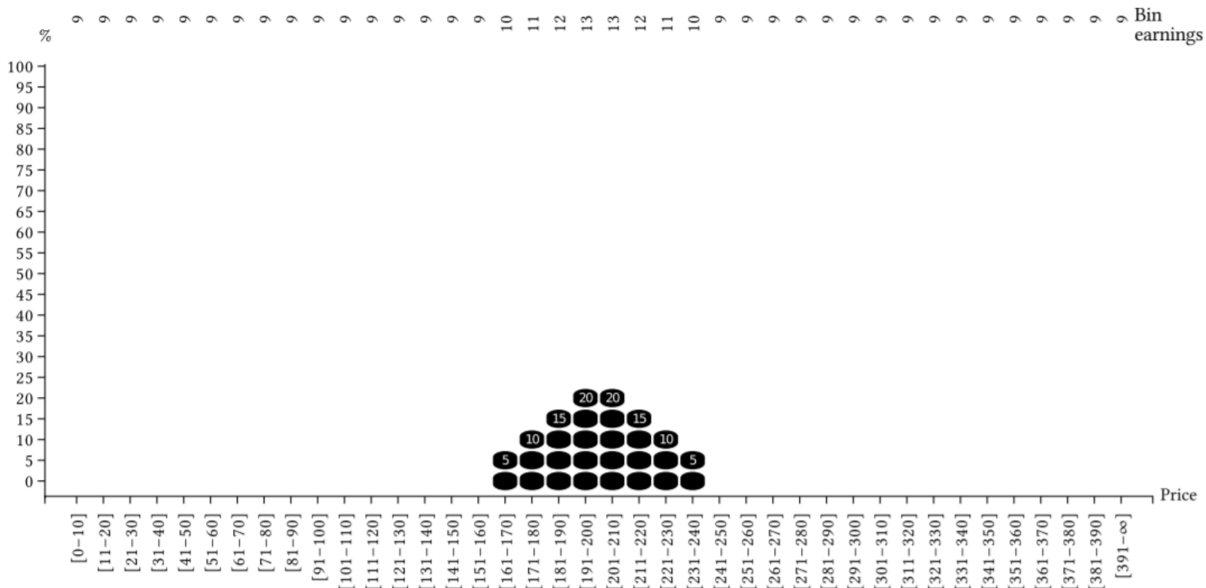
In addition to the money you earn from dividends and trading, you can make money by accurately forecasting the trading prices of all future periods. You will indicate your forecasts using the prediction tool shown below.

Predictions are produced in the following way. The range of prices is divided in intervals of 10, except for the last one that is valid for all prices greater than 390. You have 20 tokens, that you can put in the different prices that you believe will be next period's realized price.

In the bottom part of the prediction tool, you can find several pre-set distributions which you can use to speed up the process. You can, also, drag the distributions with the mouse or add and remove tokens by clicking. You will not be allowed to move forward until you assign all your tokens. Once you have assigned all of them, you will click in "Finalize" and then in "Next".

In the upper part of the screen you can see market prices for the previous periods.

The money you receive from your forecasts will depend on how many tokens you allocate on the effective price and how dispersed are your tokens. The more tokens you put in a price, the greater the payment. The more dispersed your tokens are, the lower the payment. The number of points that you will receive if the market price falls in a given interval is shown on the upper part of the tool after clicking "Finalize".



Your Payment

Within each market you receive points by predictions and by transactions. The earnings by transactions is the number of points that you accumulated at the end of period 15, after the last dividend is paid. The earnings for predictions are the sum of the points that you obtained in each period of the market.

At the end of each 15-period market, it will be randomly chosen if you are paid by your earnings in predictions or in transactions, so you need to put effort in both tasks.

Therefore, your payment in a 15 period market will be one of the following options,

1. If you are chosen to be paid by transactions,

   The money you have at the beginning of period 1
   + the dividends you receive
   + the money received from sales of shares
   − the money spent on purchases of shares
   Converted to euros at 85 points per euro,

OR

2. If you are chosen to be paid for your forecasts,

The sum of the earnings from all forecasts for the 15 periods in a market, transformed into cash at the end of each market at 85 points per euro.

A.3 Questionnaire

A.3.1 Before Session

Understanding questions

Prediction Tool

Please, make predictions using the tool. You have to allocate the tokens to the values that you think will be the values tomorrow. For example, if you think that the price tomorrow is going to be 5, 10 or 50, you have to put tokens on those values. Do not forget to click "Finalize" after you are done!

1. Put 25% of tokens on the price 96, 10% on price 106, 50% on price 198, and 15% on price 210.

This means that you think the price 198 is the most likely result that happens with a 50% probability, the second price you think is more likely to happen is 96 which happens with 25% probability and so on.

1. Now use the mouse to drag the distributions towards the sides, so that there is no tokens on prices 96, 106, 198 and 210.

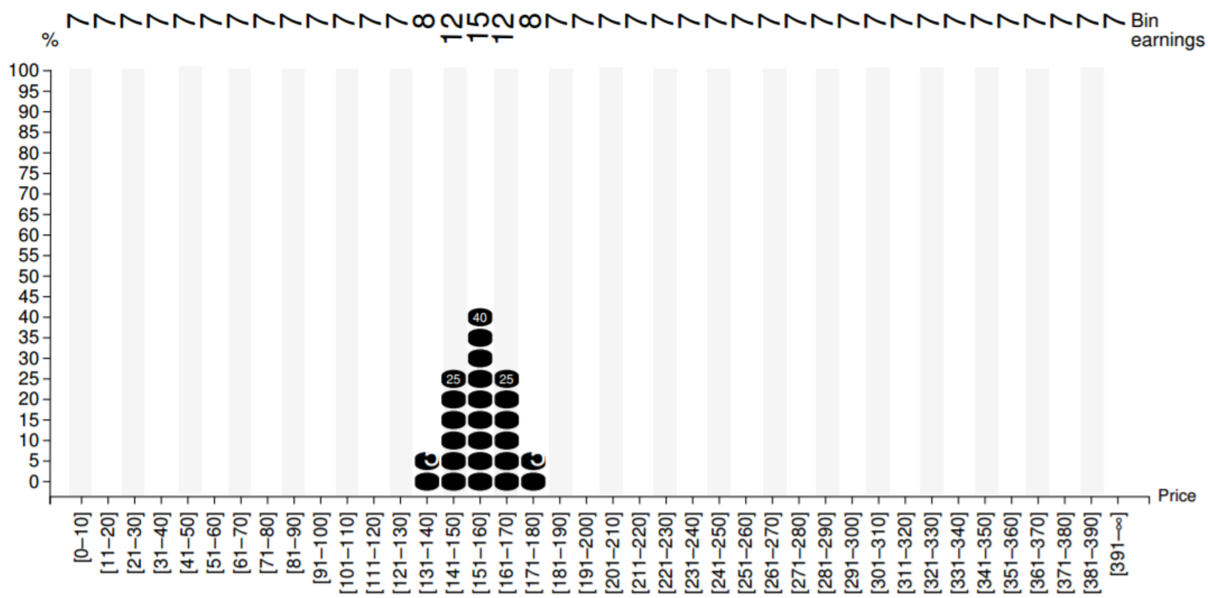
Asset Trading

You have been assigned some shares. In this context, a share is a piece of paper that pays a return in each of the remaining periods, with a life of 15 periods. The share pays returns of $\{0, 4, 14, 30\}$ with equal probability. Therefore, the return can be 14 in period 1, 0 in period 2, etc. The shares are worth 0 after finishing the last period.

1. What is the average dividend payment on the share in period 3?
   Answer: 12 francs

2. What is the average total dividend that you will receive if you hold the share from period 3 through to the end of the market round (i.e. the end of period 15)?
   Answer: 156 francs

3. What is the maximum possible dividend that you can receive if you hold the share from period 3 through to the end of the market round?
   Answer: 390 francs



4. What is the minimum possible dividend that you can receive if you hold the share from period 3 through to the end of the market round?
   Answer: 0 francs

Prediction Tool II

1. How many francs would you win if the price is 155?
Answer: 15

2. How many francs would you win if the price is 180?

Answer: 8

Cognitive Reflection Test

Payment randomly for a selected question at the end

(1) A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? _____ cents

Answer: 0.5

(2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes

Answer: 5

(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ day

Answer: 47

A.3.2 After Session

Risk Aversion Lotteries

Which bet would you take?

a) 1/10 of $2.00 9/10 of $1.60 or 1/10 of $3.85, 9/10 of $0.10

b) 2/10 of $2.00, 8/10 of $1.60 or 2/10 of $3.85, 8/10 of $0.10

c) 3/10 of $2.00, 7/10 of $1.60 or 3/10 of $3.85, 7/10 of $0.10

d) 4/10 of $2.00, 6/10 of $1.60 or 4/10 of $3.85, 6/10 of $0.10

e) 5/10 of $2.00, 5/10 of $1.60 or 5/10 of $3.85, 5/10 of $0.10

f) 6/10 of $2.00, 4/10 of $1.60 or 6/10 of $3.85, 4/10 of $0.10

g) 7/10 of $2.00, 3/10 of $1.60 or 7/10 of $3.85, 3/10 of $0.10

h) 8/10 of $2.00, 2/10 of $1.60 or 8/10 of $3.85, 2/10 of $0.10

i) 9/10 of $2.00, 1/10 of $1.60 or 9/10 of $3.85, 1/10 of $0.10

j) 10/10 of $2.00, 0/10 of $1.60 or 10/10 of $3.85, 0/10 of $0.10

Exit Questionnaire

1. What is your gender?

[Female, Male]

2. What is your age in years?

[Age]

3. Your nationality?

[Open text]

4. What is your employment status?

[Full-time, Part-time, None]

5. If you are a student, what is your major?

[Open Text]

6. What is the level of the highest degree you are currently studying?

[Bachelor, Master, Doctor/PhD, Other]

7. Did you ever make a mistake in entering a price, or clicked a wrong button? If so, please tell us exactly what went wrong and in what period:

[Open text]

8. Did you find the instructions in the market experiment clear and understandable? What if anything could be improved?

[Open Text]

Appendix B

B.1 Model with Entry

The modeling of entry simplifies Hopenhayn (1992) in a simpler setup, similarly to Aragon (2017) in which insufficient entry is allowed.

There is an infinite and discrete number of entrants, $H = 1, 2 \ldots.$ Each entrant has to pay a cost wc_e^i to know the productivity of their idea. This is in terms of the current cost of capital, w, which is determined in the market for capital. Entrants are ordered so that $c_e^1 < c_e^2, \cdots < c_e^{h-1} < c_e^h < \ldots.$ A succesful entrant provides a social value of Ψ. This value is created with either one of the banks.

They will enter if the expected benefits of entering outweigh the costs,

$$V^e \equiv \sum_{i:\pi^i>0} E(\pi^i) > wc_e^i$$

In other words, the potential entrants pay an entry cost of c_e^i in terms of units of labor and take a productivity draw from the distribution ν, with $\sum_i \nu_i + \nu_o = 1$ and every element being positive. ν_0 is the probability that the idea is unproductive and the entrepreneur finds it unprofitable to enter the market.

I assume the following regarding entry:

Assumption 3.
- *In the equilibrium without the aggregate shock, the incumbent firms are in equilibrium and there is no entry. In other words, without the shock we have $V^e < w^\star c_e^1$*
- $E(\nu) > \inf Z$

In this setup, assuming a negatively sloped labor demand function, the problem becomes worse. The bank keeps the firm afloat, without considering the entry externality. The reason is that it cannot make sure that the entrant will make a deal with them instead that with the other bank. In this way, the bank keeps the market wage higher, avoiding the cleansing effect of the recession.

This is stated in Proposition 9.

Proposition 9. *When a bank evergreens, w increases and entry decreases* $V^e < w^\star c_e^1$, *reducing social welfare.*

B.1.1 Descriptive Statistics of Unmatched Data

Table B.1 – Descriptive Statistics of All Firms

Firms				
	Obs	Mean	Min	Max
Net Investment/Capital	132,14	0,17	-1,06	6,79
Short Term Debt/Assets	156,72	0,64	0,00	1,32
Long Term Debt/Assets	137,02	0,12	0,00	1,05
Debt/Assets	136,93	0,70	0,05	1,64
Sales Growth	103,83	0,06	-3,57	5,22
log(Assets)	157,11	14,99	10,93	19,22
Net Worth/Assets	136,93	0,35	-1,57	0,99
Long Term Debt/Debt	136,93	0,17	0,00	1,00
Ebitda/Debt	136,79	0,18	-0,35	1,65

Table B.2 – Descriptive Statistics of All Banks

Banks				
	Obs	Mean	Min	Max
Leverage	169,69	18,22	0,07	95,00
Assets	182,93	1,01	0,00	18,10
Capital	169,69	0,07	0,00	0,34
Risk Adj Capital	168,31	0,06	0,01	0,26
Tier 1 Capital Ratio	168,32	9,41	0,00	64,42

Bank Assets and Capital are in billions of Euros.

B.2 Creation of Variables for Empirics

Creation of liquidation/absorption index / Weak Banks / Weak Firms.

Amadeus provides data on ownership structure of firms (name and percentage ownership). There is no time series information for this variable; the only reported ownership structure information in Amadeus corresponds to the latest value. However, using the 2006 Amadeus CD, I was able to access the data from that year. In this way, it is possible to compare ownership structure from before and after the crisis.

I construct three measures of liquidation or absorption:

- A firm is "liquidated" when the ownership structure of over 50 percent of its shares changed owners
- A firm is "absorbed" when the bank either becomes an owner (without having been one before) or its ownership increases by 50%.

B.2.1 Creation of zombie index

Caballero et al. (2008) provide the first paper to identify zombie firms in Japan using a novel technique. They create a lower bound of the minimum required interest payment for each firm each year,

$$R^*_{it} = rs_t \times BS_{i,t-1} + \left(\frac{1}{5} \sum_{j=0}^{4} rl_{t-j} \right) BL_{i,t-j} + \min(rcb_{t-4}, \ldots, rcb_t) \times Bonds_{i,t-1}$$

where

- $BS_{i,t-1}$: short term bank loans (<1 year)
- rs_t: average short term prime rate in year t
- $BL_{i,t-j}$ represent long term bank loans of maturity j
- rl_{t-j} average long term prime rate in year t
- $Bonds_{i,t-1}$ total bonds outstanding of maturity j
- $\min(\ldots)$ is the minimum observed coupon rate for convertible corporate bond issued over the last five years, respectively.

$R^*_{t,i}$ is a lower bound on interest payments for firm i in year t. Then, the key point is to compare the actual interest payments, $R_{i,t-1}$ in the previous period with this hypothetical lower found:

$$R_{i,t} < R^*_{i,t-1}$$

If the inequality holds, Caballero et al. (2008) say that the firm is receiving subsidized lending and is therefore being supported by the bank.

Given that Amadeus does not report the composition of liabilities but I do observe the maturity structure, I created a minimum bound using the prime rate for short term and long term bank debt.

I addition to the "financial support" criterion of Caballero et al. (2008), I add a solvency condition.[1] This is necessary as many large, healthy firms may

[1] Acharya et al. (2016) also use a similar criterion.

receive cheap credit for reasons different than financial support. I consider a firm a zombie if they receive subsidized lending and the profits from the previous periods would not have been enough to cover the services of debt at the hypothetical lower bound. Mathematically,

$$EBIT_t < R_t^* B_{i,t-1}$$

Where $EBIT_t$ are EBITDA profits in t and $B_{i,t-1}$ is the firm debt in the previous period.

B.2.2 Creation of Tobin's q

Tobin's marginal q, is the ratio of the market value of an additional unit of capital to its replacement cost or, in other words, the net present value of maximized profits divided by the investment good price.[2] Mathematically this implies that the Marginal Q, MQ_t is given by

$$MQ_t = \frac{1}{p_t^I} E_t \left[\sum_{j=0}^{\infty} \beta^t (1-\delta)^t \pi_{t+j} \right]$$

Where p_t^I is the price of investment good, δ is depreciation, π is max profits divided by capital stock in $t+j-1$, $\beta = \frac{1}{1+r}$ is the discount rate with r representing the effective rate of all loans.

Assuming r and π follow random walks it is straightforward to show that

$$Mq_t = \frac{\pi_t}{p_t^I} \frac{1+r_t}{r_t+\delta}.$$

B.3 Assumption on Returns

Throughout the paper I focused on the case in which the incentive compatibility of the firm between investing and storing crosses twice.

For very small b, it is obvious that $E\pi^I > E\pi^S$, as investing is more profitable. For very large b, it is also obvious that $E\pi^I > E\pi^S$ holds, as the probability of bankruptcy tends to one in both cases and therefore the most profitable investment dominates.

The interesting case is the case in which storage dominates investment for intermediate levels of b. I will show that this holds for a certain range of $\bar{y}, \sigma_\epsilon$. Moreover, using only gambling, the results of the paper continue to hold, and are described in section B.4.1.

[2] Hayashi (1982) shows that this corresponds to an optimal investment function from a firm facing adjustment costs.

Using the truncated normal distribution the firm will prefer to store rather than invest if,

$$\Phi(\beta)\left[\bar{y}-\sigma_\epsilon\frac{\phi(\beta)}{\Phi(\beta}\right]+(1-\Phi(\beta))V^\ell<\Phi(\beta')\left[y-\sigma_\nu\frac{\phi(\beta')}{\Phi(\beta'}\right]+(1-\Phi(\beta'))V^\ell$$

where $\beta=\frac{b-\bar{y}}{\sigma_\epsilon}$ and $\beta'=\frac{b-y}{\sigma_\nu}$

$$\left(\Phi(\beta')-\Phi(\beta)\right)V^\ell+\bar{y}\Phi(\beta)-y\Phi(\beta')+\sigma_\epsilon\phi(\beta')-\sigma_n u\Phi(\beta)<0$$

Which simplifies to,

$$\frac{\bar{y}\Phi(\beta)-y\Phi(\beta')}{\Phi(\beta')-\phi(\beta)}<-V^\ell-1$$

The RHS is a positive amount, as V^ℓ is negative. The derivative of the RHS with respect to $\bar{y}$ is negative, whereas the derivative with respect to σ_ϵ is positive. Therefore, for each $\bar{y}'$, there is a σ_ϵ' such that the expression is true.

B.4 Proofs

Proposition 1 If investment is efficient and disruption costs are below $\bar{\phi}$, $b^C<\bar{b}_1$.

Proof. The competitive rate is given by,

$$b^C=\frac{1}{\alpha(b^C)}(RX-(1-\alpha(b^C)\ell)$$

The threshold for the incentive compatibility of the firm in normal times is,

$$b_1=\frac{\alpha\bar{y}-hy-\alpha X}{h(b_1)-\alpha(b_1)}-V^\ell$$

with $h(b_1)>\alpha(b_1)$arranging,

$$\alpha^C\left(\alpha\bar{y}-hy-\alpha X\right)-\alpha^C(h-\alpha)V^\ell<(h-\alpha)RX-(h-\alpha)\ell\alpha^C$$

where $h=h(\bar{b}_1)$, $\alpha=\alpha(\bar{b}_1)$ and $\alpha(b^C)=\alpha^C$. Operating,

$$\alpha^C\alpha\left(\bar{y}-y-X-V^\ell\right)+(hy-\alpha y)-\left((h-\alpha)\alpha^C+\alpha\alpha^C\right)V^\ell<(h-\alpha)\left(RX-\ell(1-\alpha^C)\right) \tag{B.1}$$

Given that $h(b_1)>\alpha(b_1)$, investment is efficient and $V^\ell<0$, all terms from the LHS are positive. A sufficient condition for the RHS to be negative if $(1-\alpha)\ell>RX$. Therefore, it is possible to construct nonnegative disruption costs, $\bar{\phi}$ such that the expression is satisfied. □

Proposition 2 If investment is efficient and disruption costs are below $\bar{\phi}$, then $b^{inv}_{\max} > b^C$

Proof. Recall that

$$b^C = \frac{1}{\alpha(b^C)}(RX - (1 - \alpha(b^C)\ell)$$

and

$$b^{inv}_{max} = \ell - \frac{\alpha(b^{max})}{\alpha'(b^{max})}$$

We know that $\alpha'(\cdot) < 0$. Therefore, $b^{inv}_{max} > \ell$. Comparing the two equations we obtain,

$$b^C \equiv \frac{1}{\alpha(b^C)}(RX - (1 - \alpha(b^C)\ell) > \ell - \frac{\alpha(b^{max})}{\alpha'(b^{max})} \equiv b^{inv}_{max}$$

$$\ell - \frac{\alpha(b^{max})}{\alpha'(b^{max})} > \ell > RX$$

The second inequality comes from the fact that investment is efficient, so that the liquidation value of the firm is greater than the cost of investment.

This is true for liquidation values that are between certain bounds. Lets say disruption costs are percentual, *phi*. Then, $phi\ell = RX + \frac{\alpha(b^{max})}{\alpha'(b^{max})}$. This creates a cutoff ϕ such that the expression is true. □

Proposition 3

- $q = Prob\,(\psi < K - f(A'))$ increases if bank chooses to liquidate.
- $\pi_b^{liquidate}$ is decreasing in A.

Proof. To prove the first statement, note that the probability of liquidation for a bank is given by $q = Prob\,(\psi < K - f(A'))$, where ψ is the shock to bank profitability, K is the capital requirement. If the firm's assets are written off, then Assets are then $A' < A$. Then, $q(A') < q(A)$. A' are bank assets. The second statement is proving by writing the profit of the bank when liquidating a firm,

$$\ell Rq(A) + (1 - q(A))\,V^B \equiv \tilde{\ell}R$$

Where V^B is the value if liquidated of the bank. All else constant, this is decreasing in $q(\cdot)$. □

Proposition 4 When firms are in debt overhang, liquidation risk increases and investment decreases. Social welfare decreases.

Proof. When the firms are in debt overhang (i.e, bank holds monopoly power) then, by Proposition 2, the effective interest rate on debt that firms pay will be higher than in the competitive market. Given that $\alpha(b)$ is decreasing in b, liquidation risk, $1 - \alpha(b)$ increases. Investment is only a zero or one variable. If Investment is 1, it would also still be 1 in the competitive market (i.e, at a lower interest rate). However, liquidation risk is higher meaning that overall expected aggregate surplus is lower. If investment is 0, it would still be 1 in the competitive market, as investment is efficient. In this case, investment is lower and social welfare is lower because of the lower output. □

Proposition 5 *(Zombie firms)* If the firm is in debt overhang and investment's efficiency is below η^*, then there exists bounds A^* of bank assets, ℓ^* and y^* such that

$$\pi^B_{inv}(\bar{b}_1) < \pi^B_{store}(y)$$
$$\pi^B_{liq} < \pi^B_{store}(y)$$

for all $\ell > \ell^*$ or all $y > y^*$

Proof. We need to verify in which case the profit of the bank investing evaluated at the maximum feasible payment that can be achieved (given the incentive compatibility) is greater than the profit of keeping the firm afloat and obtaining the maximum possible with storage in period 2. This is,

$$\pi^B_{inv}(\bar{b}_1) < \pi^B_{store}(y)$$
$$\alpha(\bar{b}_1)\bar{b}_1 + (1-\alpha(\bar{b}_1))\ell - R(X - y_1) < h(y)y + (1-h(y))\ell + Ry_1 \tag{B.2}$$

Reorganizing,

$$\alpha(\bar{b}_1)\bar{b}_1 - h(y)y + (h(y) - \alpha(\bar{b}_1))\ell < RX \tag{B.3}$$

Replacing $\bar{b}_1$ with its value from the firm's problem and reorganizing,

$$h(y)(\ell - y) + \frac{\alpha(\bar{b}_1)h(\bar{b}_1)}{h(\bar{b}_1) - \alpha(\bar{b}_1)}(\Delta y) + \frac{\alpha(\bar{b}_1)h(\bar{b}_1)y\alpha(\bar{b}_1)\bar{y}}{h(\bar{b}_1) - \alpha(\bar{b}_1)} - V^\ell\alpha(\bar{b}_1) < \left(R - \frac{\alpha(\bar{b}_1)h(\bar{b}_1)}{h(\bar{b}_1) - \alpha(\bar{b}_1)}\right)X \tag{B.4}$$

$$\frac{\alpha(\bar{b})h(\bar{b}_1)(\Delta y + y\alpha\bar{y})}{h(\bar{b}_1) - \alpha(\bar{b}_1)} - V^\ell\alpha(\bar{b}_1) - \alpha\ell < X\left(R - \frac{\alpha h}{h - \alpha}\right) \tag{B.5}$$

If we call $y = \kappa\bar{y}$ with $\kappa > 1$ (where κ is the efficiency of investment),

$$\frac{\alpha(\bar{b})h(\bar{b}_1)((\kappa - 1)y + \kappa y\alpha)}{h(\bar{b}_1) - \alpha(\bar{b}_1)} - V^\ell\alpha(\bar{b}_1) - \alpha(\bar{b}_1)\ell < X\left(R - \frac{\alpha(\bar{b}_1)h(\bar{b}_1)}{h(\bar{b}_1) - \alpha(\bar{b}_1)}\right) \tag{B.6}$$

The derivative of the LHS with respect to y shows that it is decreasing if $\kappa < \frac{1}{1-2\alpha(\bar{b}_1)}$ thus providing the condition for maximum profitability of investment such that it is not in the interest of the bank to lend. The derivative of the

RHS with respect to y is zero. Therefore, the greater the y, the bank has more incentives to evergreen.

Now, all that remains to prove is that the profit of liquidation is smaller than $\pi^B_{store}(y) < \tilde{\ell}R$. Therefore,

$$\pi^B_{store}(y) > \ell R Prob\left(\psi < K - f(A')\right) + \left(1 - Prob\left(\psi < K - f(A')\right)\right) V^B$$

Given that the LHS is unaffected by A and the RHS is decreasing in A, there exists an treshold capitalization for the bank, $\tilde{A}$ such that this expression is true.

For the second part of the theorem we can see that in equation B.6, the derivative of the LHS with respect to ℓ is negative. □

Proposition 6 In a situation of debt overhang, it is welfare maximizing to do a debt haircut and redistribute firm's profits ex post.

Proof. By Proposition 2 we know that social welfare is inferior when the bank has monopoly power over the firm. Say the effective rate is $\tilde{b}$. A debt haircut of $\tilde{b} - b^C$ allows the firm to invest at the competitive rate. Social surplus is then maximized. A planer can redistribute these benefits ex post and make everyone better off. □

Proposition 7 In the presence of zombie firms, There exists a cutoff $\underline{R}$,such that $\forall R > S$, a decrease in R does not induce investment.

Proof. Rearranging equation B.6, the firm stores if

$$\frac{\alpha(\bar{b})h(\bar{b}_1)((\kappa - 1)y + \kappa y\alpha)}{h(\bar{b}_1) - \alpha(\bar{b}_1)} - V^\ell\alpha(\bar{b}_1) - \alpha(\bar{b}_1)\ell + X\frac{\alpha(\bar{b}_1)h(\bar{b}_1)}{h(\bar{b}_1) - \alpha(\bar{b}_1)} < XR \tag{B.7}$$

We can see that there exists a sufficiently low R such that the RHS is lower than the LHS. For all R that do not satisfy that cutoff, the firm prefers to invest.

Moreover, it induces less liquidation as $R\tilde{\ell}$ decreases. □

Proposition 8 In the presence of zombie firms, there exists a bound A_1 such that for all $A < A_1$, the bank evergreens and for all $A > A_1$ the bank liquidates.

Proof. From Proposition 5, we know that in this case,

$$\pi^B_{inv}(\bar{b}_1) < \pi^B_{store}(y) \tag{B.8}$$

and that

$$R\tilde{\ell}(A) < \pi^B_{store}(y) \tag{B.9}$$

For all capitalizations $A < A_1$ such that Equation B.9 is satisfied, the bank will continue to evergreen.

For all capitalization $A' > A_1$ such that equation B.9 is not satisfied, it is also true that $R\tilde{\ell}(A) > \pi^B_{inv}(\bar{b_1})$ □

Proposition 9 When a bank evergreens, w increases and entry is reduced. Welfare decreases.

Proof. By keeping a firm in the market, the bank keeps market wage w at $w^* > \tilde{w}$. This decreases entry and welfare by the same arguments as in Aragon (2017). □

B.4.1 Gambling Only

If the assumption in Appendix B.3 does not hold, the main results of the paper still remain.

The double crossing condition in this case is

$$\alpha(b)(\bar{y} - b + E(\cdot)) + (1 - \alpha(b))V^\ell = \gamma\tilde{y} - \gamma b + (1 - \gamma)V^\ell$$

Which leads to an indifference of

$$\bar{\bar{b}} = \frac{1}{\alpha(\bar{\bar{b}}) - \gamma}\Big(\alpha(\bar{\bar{b}})\bar{y} - \gamma\tilde{y})\Big) + V^\ell \tag{B.10}$$

Propositions 2 to 4 are unchanged by this assumption. For proposition 6 to 9 we need Proposition 5 to hold.

For Prosposition 5 to hold with only gambling and investment, need that

$$E\pi^B_{inv}(\bar{\bar{b}}) < E\pi^B_{store}(y_1)$$

From Proposition 4, we had that

$$\alpha(\bar{\bar{b}})\bar{\bar{b}} - h(y)y + (h(y) - \alpha(\bar{\bar{b}}))\ell < RX \tag{B.11}$$

Replacing with B.10,

$$\frac{\alpha(\bar{\bar{b}})(\alpha(\bar{\bar{b}})\bar{y}) - \gamma\tilde{y})}{\alpha(\bar{\bar{b}}) - \gamma} - h(y)y + (h(y) - \alpha(\bar{\bar{b}}))\ell < RX$$

Operating, and taking the limit for $\gamma \to 0$,

$$\frac{\alpha(\bar{\bar{b}})\kappa - h(y)}{\alpha(\bar{\bar{b}}) - h(y)} y - \ell < \frac{RX}{\alpha(\bar{\bar{b}}) - h(y)}$$

Taking derivatives it is immediate to see that the expression holds for high y and low ℓ.

Appendix C

C.1 Assumption

The paper assumes that after the aggregate shock, incumbent firms decrease their size. This is not obvious, as the bankruptcy of a firm allows the incumbents to capture the flow of workers at lower wages.

From market clearing,

$$n^S(w^\star) = \sum_i n_i^d(w^\star | A_i)$$

Differentiating totally with respect to the aggregate shock A and completing elasticities, we get that

$$\frac{dw}{dA} = \frac{\sum_i \eta_A^{d,i}}{\eta_w^S - \sum_i \eta_w^{d,i}} \frac{w}{A}$$

where $\eta_k^{j,i}$ is the elasticity of $j = Supply, Demand$ with respect to variable k of firm i. Since the aggregate shocks enters multiplicatively, $\eta_A^{d,i} = 1$.

We have to compare that effect to the effect of the bankruptcy of the small firm, n_3. Since both are shifters of the aggregate demand of labor, $\frac{dw}{dA} = \frac{dw}{dn_3}$. Therefore, a sufficient condition so that labor demand falls for the firms that stay in the market is that $\Delta A > n_3$. That is, the aggregate shock needs to be larger than the smallest firm's size.

Moreover, if the elasticity of labor supply is large enough, then the effect remains even for smaller aggregate shocks.

All the results hold, however, if wages are "sticky" (discussed in Appendix C.3).

C.2 Proofs

Proposition 1 Given the previous set of assumptions, the indirect profit function satisfies the following,

- $\pi_z(w^\star, r^\star|z_i)$ is increasing in z
- $\frac{\partial f(z_i, n_z^\star)}{\partial z} > 0$
- $\frac{\partial \pi_z(\cdot)}{\partial z} > \frac{\partial b_z(\cdot)}{\partial z}$

Proof. First assertion derives Envelope theorem and assumption **A.1**, since $\frac{\partial \pi^\star}{\partial z} = pf_z(n^\star, \cdot) > 0$. Second assertion is straightforward from Assumption **A.1**. Third assertion comes from Hotelling lemma, in which $\frac{\partial \pi^\star}{w} = -n$. From profit maximization this is also equal to $wrf_n(n^\star, \cdot)$. From Assumption **A.1**, this is smaller than $pf_z(n^\star, \cdot)$. ” □

Proposition 2 There are three cutoffs $\bar{\xi}_0 < \bar{\xi}_1 < \bar{\xi}_2$ such that

- For a small shock, $\xi < \bar{\xi}_0$ all firms make positive profits.
- For an intermediate shock $\xi \in \left[\bar{\xi}_0, \bar{\xi}_1\right]$ low productivity firms exit and intermediate and high productivities firm stay.
- For a large shock $\xi \in \left[\bar{\xi}_1, \bar{\xi}_2\right]$ low and intermediate firms exit, while high productivity firms stay.

Proof. If the shock $\frac{1}{\xi} < \frac{\pi_L}{\frac{d\pi}{dA}}$ then by Assumption 1, profits are still positive for all firms. By Proposition 1, all firms demand demand less, decreasing wages and labor demand. Given Proposition 1, there is a hierarchy of profit to debt ratios that is decreasing in firm size. Therefore the debt overhang is worse for small firms. The rest of the proof follows the same logic. ” □

Proposition 3 The planner problem,

- In Normal times, coincides with the competitive equilibrium;
- In Crisis times, no firm goes bankrupt, but they decrease their size.

Proof. First part of the proposition follows from the fact that there are no externalities or frictions during normal times. Second part of the proposition derives from the planner reoptimizing. As long as the shock does not render firms with negative productivity, which is true for any $\xi > 1$, they still have social value and would stay in the market to avoid disruption costs (given **A.2**, albeit with a smaller size (by Proposition 1). ” □

Proposition 4 (*Optimal Haircuts*). Given a shock $\xi \in \left[\bar{\xi}_1, \bar{\xi}_2\right]$, there is an optimal debt haircut ϕ for every firm in the economy; such that low productivity firms go bankrupt but medium productivity firms stay in the market. Both consumers and entrepreneurs are better off. The policy does not restore full employment. Moreover, the policy can be implemented also by taxes on profits.

Proof. With a shock $\xi \in \left[\bar{\xi}_1, \bar{\xi}_2\right]$, medium and low productivity firms would go bankrupt if no intervention.

In order to avoid low productivity firms debt forgiveness must be total, by Proposition 1. This causes consumption of agents to be equal to $\sum_{i=H,M,L}(1+r)w_i^{\star,'}n_i^{\star,'}$ or given the feasibility constraint, $\sum_{i=H,M,L} y_i^{\star,'} - \sum_{i=H,M,L} \pi_i^{\star,'}$.

By Proposition 2, With intermediate bailout -letting the intermediate firm in the market but allowing bankruptcy of the low productivity firm-, the consumer gets $\sum_{i=H,M} \tilde{w}_i\tilde{n}_i + \phi b_L$. If there is no bailout whatsoever, only the big firm is left in the market and consumer gets $\hat{w}_H\hat{n}_H + \phi\sum_{i=L,M} b_i$.

By Proposition 1, production under each case is smaller and wages lower when we allow for bankruptcy. By Assumption in C.1, the effect on wages is lower than that on output.

Using the fact that the aggregate shock is multiplicative; then, a partial haircut is better than laissez-faire if

$$\hat{y}_H - \tilde{y}_H + (b_L + b_M)\phi < y_M$$

And is better than full haircut if

$$(y_H^{\star,'} - \tilde{y}_H + y_L^{\star,'} - \tilde{y}_M + y_M^{\star,'} - \tilde{y}_M) + > b_L\phi$$

Given decreasing returns to scale and multiplicativity of the aggregate shock, then , there exists a distribution of productivities and disruption costs, such that the output from firm M is higher than the change in output in the larger firm. ” □

Proposition 5 Assuming the ω_i is increasing in z_i, there is a distribution, $\{Z_i\}_{i\in\{L,H,M\}}$ that Proposition 1 and Proposition 2 hold.

Proof. Simply define $\tilde{z}_i = \omega_i z_i$. Then, **A.1** holds. Then, Proposition 1 and Proposition 2 hold. ” . □

Proposition 6 A bailout on a low productivity firm decreases the average productivity over the long term.

Proof. Given Proposition 2, an aggregate shock affects more small firms, thus “cleansing”. Under the previously stated conditions, without any action this would lead to a lower wage, $\tilde{w} < w^*$.

Without any action, smallest firm goes bankrupt and wage is $\tilde{w} < w^*$, and therefore entry cost for the potential entrant with the lowest entry cost would be $\tilde{w}c_1^e$. If $\tilde{w}c_1^e > V^e$, the entrepreneur enters with a larger expected productivity than the entrant. Expected wage becomes w^{**}, which is higher than w^*. If $\tilde{w}c_1^e < V^e$, there is no new entrant and average productivity is higher, as z_1 is lower than z_2 and z_3.

By saving the small firm, wage becomes $\tilde{\tilde{w}} > \tilde{w}$. Since the likelihood that $c_1^e > \frac{V^e}{\tilde{w}}$ is greater than that of $c_1^e > \frac{V^e}{\tilde{\tilde{w}}}$, the result is proven. ”

$\square$

C.3 Sticky Prices

To include sticky prices in a parsimounious way, I assume that wages (and the consumption good price, which acts as numeraire) are preset in $t = 0$. Given that the shock is unanticipated, wages will be preset at the equilibrium price, w^*. The timing is as in Figure C.1.

When the unanticipated shock occurs, the labor market does not clear. In this context, labor demand falls unambiguosly for all firms given Proposition 1, and therefore the equilibrium level of labor, $\hat{n}$. There is involuntary unemployment of magnitude $n^* - \hat{n}$. Therefore, all the results hold without the need of the assumption in Section C.1.

$t = 0$	$t = 1$	$t = 2$
Workers consume and lend Firms demand working capital **Wages are preset**	Labor market clears Workers receive w Firms produce $f(A, n)$ Shock	Firms pay back debt Consumption takes place

Figure C.1 – Timing of the model

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